BRITISH VOLUME
Vol. 35-B, No. 4

NOVEMBER 1953

The Journal of Bone and Joint Surgery

John Haddy James

THE JOURNAL OF THE ENGLISH-SPEAKING WORLD

PUBLISHED JOINTLY IN LONDON, ENGLAND
AND BOSTON, UNITED STATES OF AMERICA

The Journal of Bone and Joint Surgery

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Commencing in January 1954, the Journal will be published in ten annual numbers. The six American numbers will be issued on January 1, April 1, June 1, July 1, October 1, and December 1; and the four British numbers will be issued on February 16, May 16, August 16, and November 16. **The subscription price,** payable in advance, for the four British numbers alone, is £3 (10 dollars), or for the six American numbers alone, £4 (13 dollars). The combined subscription price for both British and American volumes is £6 (20 dollars).

The Journal is owned, and is published in the United States of America, by the American Orthopaedic Association. American Editorial Offices: 8 The Fenway, Boston, Massachusetts, U.S.A. Assistant Editor to the American Board: Miss Florence L. Daland.

The Journal is published in the United Kingdom by Messrs E. & S. Livingstone Ltd., 16–17 Teviot Place, Edinburgh; and Ludgate House, Fleet Street, London. British Editorial Offices: 82 Portland Place, London (Tel. Langham 1378). Editorial Secretary to the British Board: Miss Jean Barnes.

THE JOURNAL

OF

BONE AND JOINT SURGERY

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November 1953

PUBLISHED IN LONDON BY MESSRS E. & S. LIVINGSTONE LTD.

AMERICAN VOLUME PUBLISHED AT 8 THE FENWAY, BOSTON, MASS.

THE JOURNAL
OF
BONE AND JOINT SURGERY

OFFICIAL PUBLICATION OF THE

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The Journal of
Bone and Joint Surgery

EDITORIALS AND ANNOTATIONS

THE TREATMENT OF TRAUMATIC PARAPLEGIA

There can be no doubt that the patient with a spinal injury has a much better chance now than he has ever had in the past. In the old days it was too often the case that, unless there were sufficient resources to provide special and constant nursing, bedsores and urinary infection were inevitable and often fatal. If these early hazards were overcome, the patient spent the rest of his life as a total invalid at home or in some kind of hospital for incurables, a pathetic burden to himself, his family and the community. Nowadays improved hospital facilities and nursing save many lives in the acute stage, and rehabilitation subsequently makes it possible for many of these patients to lead fairly active, useful and happy lives. In this development, the special centres for paraplegics have played a notable part, not only in the cases which they deal with themselves but also in setting a standard for others, and in showing what can be done. If there were enough such centres, the immediate mortality could be reduced to negligible proportions and rehabilitation would be more generally effective than it is now.

But the fact is that there are not enough special centres, in this country or America, and most patients will still have to be dealt with in general and orthopaedic hospitals. Despite the growing toll of the road and of industrial accidents, spinal injuries are not so common that any one person outside a special centre can become expert in their management. Consequently, reports from these centres continue to be valuable.

In this number of the Journal Holdsworth and Hardy report sixty-eight cases of a particular kind of injury, fractures in the thoraco-lumbar region with paraplegia. These injuries, often involving both the spinal cord and the roots of the cauda equina, present peculiar problems of neurological interest. As with other kinds of vertebral fractures and dislocations, the immediate problem is the vertebral injury; some fractures in the thoraco-lumbar region are unstable, and for these Holdsworth and Hardy recommend early plating of the spinous processes above and below the lesion to restore stability. This seems to be an easy, safe and effective procedure, and it means that the patient can be moved about from the time of the operation. Early and frequent changes of posture are probably the most important factors in the prevention of pressure sores and there is much to be said for any procedure that will make prolonged immobilisation of the patient unnecessary. It is also likely that this kind of internal fixation will prevent progressive angulation or other deformities when the upright posture and weight bearing are resumed.

Apart from the vertebral injury, the functional result is usually determined by the extent of the damage to the spinal cord and the roots of the cauda equina. The cord injury is greatest at the moment of the vertebral trauma and is for the most part irreparable. But the lumbar roots of the cauda equina, lying alongside the lower end of the cord, may escape serious injury, or, if they do not, some recovery is possible. Thus in the most favourable cases the patient may be left with only a defect in the sacral segments, the lumbar innervation being largely preserved. This is of great value in walking because enough hip and knee movements may remain to save the patient from having to swing his lower limbs lifelessly on

crutches; there is therefore a great effect on the patient's morale. If there is total paralysis of the lower limbs, many patients prefer to become expert in the use of a wheel chair rather than to struggle to walk with the aid of appliances, and the choice must usually rest with the patient.

The loss of the sacral segments of the cord means loss of voluntary control of the bladder and bowel, but modern methods of treatment have considerably reduced the consequent dangers and inconveniences. The important immediate problem is the prevention of infection, and this means avoiding over-distension of the bladder from the outset. The long-term aim is the establishment of automatic emptying, and this is effective and of value to the patient only if the bladder has a reasonable volume—that is, if it has been prevented from shrinking. These ends can usually be achieved by continuous urethral drainage, with intermittent distension and suction drainage. Many prefer some form of tidal drainage apparatus but even in its simplest form it is apt to be a worry to those who are only called upon to use it once or twice a year. Holdsworth and Hardy have found that in their cases it has been sufficient to drain the bladder by an indwelling urethral catheter, to prevent shrinkage by intermittent irrigation and to avoid stagnation by suction. If infection does occur, modern chemotherapy and antibiotics are usually effective.

Despite the advances that have been made, a spinal injury remains a very serious and often tragic matter. Our efforts are directed to salving what remains of physique and morale and to restoring the patient to some kind of useful activity. So grave is the problem that the question of operation for the spinal cord lesion arises sooner or later. Such operations are usually unavailing: the spinal cord lesion is inflicted at the moment of the injury, and, as it is usually a gross contusion or laceration, no surgical procedure is likely to help. A case may be made for removing foreign bodies, missiles and fragments of bone from the vertebral canal, but very rarely does such removal benefit the spinal cord. If lumbar puncture reveals a manometric block, the question of operation may have special difficulties. In most cases the block is due to oedema or haemorrhage of the cord, gross lesions which operation is unlikely to help, and Holdsworth and Hardy say that they have never seen any good come from it. There are, however, occasional cases of a block due to an extrathecal haematoma or extrusion of an intervertebral disc, removal of which might provide something of a decompression and be of potential benefit. Such cases can be detected only by an exploration, and most surgeons would find it difficult to deny the patient who has a block the slight chance, very slight though it is, of relief by operation. In the absence of a manometric block, there is really nothing to be said for operation, and the patient can be spared a useless procedure.

J. B. PENNYBACKER.

OSTEOARTHRITIS

Controversy no longer rages, as in the earlier decades of this century, over the distinction between osteoarthritis and rheumatoid arthritis, or, as in still earlier years, over the relation of both these diseases with the then fashionable gout. Osteoarthritis is now known to be a local disorder of individual diarthrodial joints. It is independent of infection and of systemic disease in general, and is brought about by abnormal mechanical conditions in conjunction with senescence, trauma or other degrading change in articular hyaline cartilage. As many recent careful studies have shown, the morbid anatomical features of osteoarthritis are the projection to a pathological extent of the alterations in joint structure commonly and indeed almost universally associated with advancing age. Such age changes, and also osteoarthritis, are common and become severe in joints much subject to mechanical stress, weight bearing or large movement. Influences that aggravate osteoarthritis are common enough; the most usual are local joint injury or disease, especially where articular cartilage has suffered, and deformities that throw abnormal stresses upon a joint. Fischer* truly wrote that "the

* FISCHER, A. (1933): Rheumatismus und Grenzgebiete. III. Berlin: Springer.

inciting conditions of the disease must be sought separately for each diseased joint," for the general or systemic influences in osteoarthritis, like acromegaly and possibly other less well defined endocrine disturbances, are either rare or seemingly unimportant.

Although age changes and osteoarthritis affect some other joints with greater frequency and equal severity, the hip joint is the seat of the most disabling and therefore the most clinically important form of the disease to which man is subject. It is thus scarcely surprising that earlier generations of morbid anatomists dissected a number of affected hip joints and published good accounts of their gross findings. One old account which is most interesting to read to-day is by Dr R. Adams* of Dublin. The following extracts from Adams's description show how astute an observer he was and how true a conception of pathogenesis he was able to formulate from the careful dissection of a few fresh specimens and the use of his unaided eye. "The fibrous capsule of the joint is greatly thickened . . . The cartilage is removed from the bottom of the acetabulum and upper surface of the head of the femur . . . The shortened neck of the femur was entirely surrounded by a number of red villous-looking productions of the synovial membrane . . . This mechanical removal of the cartilage and exposure of the interior of the cells of the bone and substitution for the cartilage of a dense inanimate enamel . . . The effects of friction . . . The form of the head of the bone becomes changed . . . Besides the effects of physical causes, a very active *vital* process is going on in the interior of the bones . . . The exuberant growth of bone . . . A very active condition of the minute arteries exists externally, giving birth to those exostotic deposits . . ." Adams it was who had earlier coined the phrase *morbus coxae senilis*, but, because the disease may occur "so early as at the age of thirty or forty" and is "the same disease precisely as described as affecting other articulations," he here substitutes the name chronic rheumatic arthritis of the hip joint. The name matters little, but it is on the whole satisfactory to see that to-day Garrod's† designation osteoarthritis is fairly universally accepted. It avoids the too general term "rheumatic" and is an escape from the conflict between the both equally correct though incompletely descriptive terms hypertrophic arthritis and degenerative arthritis.

Three papers published in this number of the Journal are concerned with different aspects of the pathological anatomy of osteoarthritic hip joints. Most of the gross features of the disease upon which these papers comment were already known to the morbid anatomists of over a hundred years ago, but this in no way detracts from the importance of the new work. Modern researches in morphological pathology tend to be concerned not so much with the discovery of new basic facts as with their more detailed analysis by the use of new technical methods, and with interpreting them in relation to pathogenesis, symptomatology or treatment. The value of a new technical approach is well illustrated in the contribution by Harrison, Schajowicz and Trueta. Landells's paper on the bone cysts and Lloyd-Roberts's paper on the capsular changes in osteoarthritis present new ideas regarding the pathogenic mechanism underlying the particular features of the disease with which each deals. All of these articles carry important implications in the field of clinical practice.

The bone cysts of osteoarthritis, discussed by Landells and described also in the paper by Harrison, Schajowicz and Trueta, did not attract much attention until their frequency came to be shown by radiography. Both the present papers show that these cysts are common in femoral heads removed at operation for clinically severe osteoarthritis. They are smoothly rounded or pyriform in outline and form just below the articular surface, and they usually show a stoma communicating with the general articular cavity. Landells concludes that the cysts arise from the intrusion of synovial fluid under pressure into the bone near the joint surface and that they represent a direct result of injury after cartilage degeneration rather than a primary degeneration within the bone. Subsequent vital reactions in the bone may,

* Adams, R. (1836–1839): *In* Cyclopaedia of Anatomy and Physiology, Vol. ii, 798–802. Edited by R. B. Todd. London: Longman, Brown, Green, Longmans, & Roberts.

† Garrod, Sir A. E. (1890): A Treatise on Rheumatism and Rheumatoid Arthritis. London: C. Griffin & Co.

of course, lead to variations in the gross and microscopical characters of the contents and environs of the cysts. Although it is certainly not to be concluded that all radiographically revealed "cysts" are of similar origin, Landells's explanation of the bone cysts of osteoarthritis deserves most careful attention, because, in times past, grossly erroneous interpretations, ranging from ischaemic necrosis to protozoal abscesses, have been made.

Lloyd-Roberts's study of the capsular changes in osteoarthritis of the hip, apart from its important clinical implications, shows that the synovial membrane often contains fragments of bone and cartilage derived from the breaking-up of the articular surfaces, and he believes that this debris provokes the low-grade proliferative synovitis and subsequent cicatrisation which are well recognised features of the chronic disease. He supports his belief with certain experimental observations.

Many aspects of the pathology of osteoarthritis are covered by Harrison, Schajowicz and Trueta, who begin by a careful and most rewarding consideration of the anatomy of the hip joint. Like almost all modern writers on the subject, they agree that osteoarthritis begins in attrition of articular cartilage, but rather unexpectedly find that cartilage changes on the femoral head appear first in non-pressure areas and that the cartilage which carries most weight and which overlies the pressure system of bone trabeculae survives best, at least until the more advanced stages of the disease.

The finding is not perhaps so revolutionary as it may at first seem, but we clearly tend to speak too glibly of pressure and friction and wear and tear as causes of osteoarthritis without sufficiently considering the nutritive influence of movement on the health of cartilage. Nothing is said, however, about the excursion of movement of those parts of the femoral head whose cartilage does disintegrate early; and cartilage erosions are also common in sites—for example, on the patella and in the acromio-clavicular joint—where range and frequency of movement may be more important than pressure. As for the terminal finger joints, osteoarthritis there has never been satisfactorily explained by simple mechanical considerations. The present study of the hip joint is of the greatest interest and points to the desirability of reviewing the mechanical conditions operating in other joints, both those prone to osteoarthritis and those relatively immune.

Amongst other important results included in this Oxford study are those relating to osteophytes. Here the vascular injection technique has been of special value. Perhaps the conclusion that "the osteophyte is the result of an attempt to revitalise degenerating cartilage" is a rather vague generalisation, carrying, moreover, a teleological implication. A more precise definition of at least one important form of osteophyte, based on these authors' findings, would be that the osteophyte results from advancing vascularisation and ossification of cartilage at points where the normal stability of the chondro-osseous junction has been lost through the degeneration of the cartilage. The authors themselves show that extra-osseous blood vessels and the process of membranous ossification participate in the growth of some of the marginal osteophytes, although endochondral ossification of damaged or degenerating hyaline cartilage is very important. "What is so damaging in osteoarthritis," they write, "seems to be not the degeneration of the cartilage but the vigorous and persistent attempt at repair. . ." There are many other interesting and provocative observations in this paper.

These three papers show not only that detailed observations can still be made in morbid anatomy, but that conventional interpretations of pathological phenomena must from time to time be submitted to critical review. DOUGLAS H. COLLINS.

TRAVELLING FELLOWS IN ORTHOPAEDIC SURGERY

The attention of fellows, members, and associates of the British Orthopaedic Association is drawn to the election of Travelling Fellows in Orthopaedic Surgery, 1954, which is noted in the Proceedings pages.

REST AND MOVEMENT*

GEORGE PERKINS, LONDON, ENGLAND

In orthopaedic surgery there are in general only two non-operative treatments, rest and movement. And although it would seem an easy matter in any particular case to decide which was the more appropriate treatment, in practice it is often hard to make a choice. The claims of rest have been advocated in the past by such master surgeons as H. O. Thomas and John Hilton, and in our own day the weighty influence of Sir Reginald Watson-Jones has been added. As a matter of fact Hilton was not so much an advocate of rest as of non-interference. But to H. O. Thomas rest was a positive treatment; it was something that had to be imposed. He believed and preached that rest had magical properties. Neither of these two very great men pointed out the harmful effects of rest. That prolonged rest can be harmful has lately been impressed upon us by the damage shown to be done to the knee joint during the treatment of a tuberculous hip.

In making a choice between rest and movement we are largely biased by tradition. For example, I was taught that in infantile paralysis the paralysed muscles must be relaxed continuously. "Never for one moment, night or day, shall the splint be removed." That was the commandment. And this would still be orthodox teaching had it not been for Sister Kenny. Naturally, Sister Kenny was an unqualified person, for the training of a doctor is such that it is not easy for him to break with tradition. I quote this example to show that even our most cherished convictions may be delusions. And just as prolonged uninterrupted splintage has largely been abandoned in the treatment of infantile paralysis, so may we reasonably hope that it will be in the treatment of injuries—and for the same reason, namely on account of the harm it does.

I make no apology for questioning orthodoxy. If orthodox views are correct they will prevail against any opposition; if they are false the sooner they are discarded the better.

The proposition I am putting forward is that movement is often better treatment than rest.

INFLAMMATION AND REPAIR

It is universally held that inflammation should be treated by rest. I would agree, provided that the term inflammation is interpreted correctly. In spite of what many pathologists say, for the clinician the terms repair and inflammation are not synonymous. When the body is attacked by a harmful agent it reacts by pouring out from its blood vessels fluid, cells and antibodies of various sorts. This initial reaction may properly be called inflammation. But there follows a second reaction. The body, having repelled the invader, sets about making good the damage that has been done. It removes dead cells and foreign debris of all kinds, and in the space created by this wholesale removal it lays down repair tissue. The first reaction—inflammation—should rightly be treated by rest, namely the cessation of function and immobilisation; but the second reaction—repair—should, I maintain, be treated by activity, namely the resumption of function and movement.

That rest as a method of treatment should in the course of time be replaced by activity is not a revolutionary idea. We all of us treat a septic finger by rest in the early phase and in the later phase strive hard to regain movement. The difficulty is to know when to make the change. It is easy in theory to formulate a rule about when to use rest and when movement. Rest holds the field so long as the cause of the inflammation is still acting and the patient has not as yet developed a specific defence against it. In the case of a bacterial invasion rest

* Robert Jones Lecture 1952

should be maintained until the patient has acquired an immunity. In the case of injury rest is never indicated because the cause of the inflammation has disappeared before the patient is even seen by the doctor. The doctor may have to apply a splint to hold torn structures in position, but the injury as such does not call for rest. Indeed, as I hope to show later on, rest is often harmful in that it creates adhesions between parts that ought normally to move freely on one another.

Inflammation and repair are not mutually exclusive. Active inflammation may still be going on in one area when in a neighbouring area repair has taken its place. Nor can one say at any one moment that inflammation has ceased and repair has begun. Consequently it is difficult clinically to determine when to switch from one treatment to the other. One must be guided by common sense, bearing in mind that inflammation ceases when the harmful agent ceases to harm, and that directly inflammation has ceased activity should replace rest as the basis for treatment.

Even if we allow that only active inflammation demands rest, we are still in difficulties, because it is not always easy to know whether the condition present is an inflammation or not. For example, in Paget's disease of bone, where normal bone is replaced by bone of a patternless structure, no one nowadays would claim that the pathological process concerned was an inflammation. We are in similar difficulties over a disease like ankylosing spondylitis where the pathology seems to be a metaplasia of the capsule rather than an inflammation.

CHRONIC ARTHRITIS

At no time is it more difficult to assess the relative merits of rest and movement than when dealing with chronic arthritis. To make our discussion easier let us divide cases of chronic arthritis into three groups: those due to a specific organism, like the tubercle bacillus; those due to degeneration such as the osteoarthritic joints; and the remainder, which for present convenience we may call infective arthritis with the proviso that many may not be caused by either bacteria or a virus.

About the local treatment of a tuberculous arthritis there is little to say except to deplore its shortcomings. In the acute phase we have nothing to offer except recumbency and immobilisation. In the chronic phase, depending on whether there is or is not a likelihood of regaining a useful range of movement, treatment consists either of movement without weight bearing, or of weight bearing without movement. Future generations will regard with astonishment the complacency with which we condemn a child to spend five years of its life on its back on a frame under the delusion that we are treating a disease. They will view us as we view the Spanish Inquisitors, and they will condemn, not our cruelty, but our stupidity. I should like to draw attention again to the harm we frequently do to other joints while we are treating one joint for tuberculous arthritis. I need not call to mind the wobbly, deformed knee associated with shortening of the leg so often seen in a patient who has been treated for tuberculosis of the hip joint.

When we come to osteoarthritis the decision whether to rest or to move the joint becomes easier if one has, as I have, clear-cut ideas on the pathology of the disease. I do not claim that my ideas on the pathology are necessarily correct; but they do give an indication of when and why to rest the joint. Osteoarthritis pathologically has two main features. First, the nourishment of the articular cartilage is faulty; in consequence the cartilage fibrillates, and where it is exposed to greatest pressure it is worn away. This aspect of the disease is immaterial to our present discussion. The second pathological feature is that the capsule shrinks so that the range of movement diminishes. The loss of movement is not of much consequence unless the patient habitually uses the extremes of movement. One often sees a man whose elbow will not extend beyond 160 degrees. The man is often unconscious of his loss because he does not ordinarily use the last twenty degrees of extension. As my colleague, Mr Furlong, picturesquely puts it, you only need full extension of the elbow for putting your

arm up a drain pipe. By contrast, at the knee, full or almost full extension is required whenever one stands. The consequence is that osteoarthritis of the elbow is clinically rare, whereas osteoarthritis of the knee is clinically common. One may see a man with osteoarthritis of the elbow on account of a loose body but not otherwise.

When a person is trying all the time to move a joint beyond the range allowed by the capsule, the capsule is subjected to constant stretching. The symptoms of osteoarthritis are in the main caused by the reaction of the capsule to this repeated stretching. A patient with an osteoarthritic hip complains of pain after use and stiffness after rest. Nothing benefits such a joint more than a period of rest during which the capsule is relieved for a while from being stretched. The rest need not be absolute; often recumbency by itself imposes sufficient restriction of movement.

From the point of view of treatment patients with osteoarthritis may be divided into three classes: those who are at work, those who are reasonably comfortable provided they do not work and those who have disabling pain even if they do no work. Patients in the third group have sufficient disability to warrant operation. Patients in the second group, not being at work, can be treated by recumbency. Patients in the first group cannot be sent to bed, for that would take them off work. Instead they are allowed to go on working, but the range of movement at the painful joint is restricted to its painless range—that is, to a range that does not pull on the shrunken capsule. The rocker shoe for a hallux rigidus is an example of this principle of treatment, and in osteoarthritis of the hip raising the shoe on the affected side acts in the same way, by abolishing the need for abduction.

But one may ask: Is it not possible to restore the capsule of the joint to its former length by, for example, stretching the joint forcibly under an anaesthetic? *A priori*, the ligament is more likely to react to force by tearing than by stretching, and this is what happens in practice. I do not believe that "bone-setting" benefits an osteoarthritic joint. But rest certainly does.

By far the most interesting patients are those suffering from what we have agreed to call infective arthritis; the disease is chronic; it smoulders on for years and occasionally flares like a volcano. I believe that prolonged immobilisation in this disease is harmful. The patient should be encouraged to move his diseased joints in spite of pain and discomfort. This raises the question whether pain is an indication for rest, as John Hilton would have us believe. All physicians with experience of rheumatoid arthritis know that splinting a joint in this disease leads to stiffness. Even in the worst cases of rheumatoid arthritis the patient retains the power of opposing the index to the thumb. Because this movement is essential to everyday existence the patient never for a day ceases to move these two digits. There is no need for him to move the outer three fingers with the result that they stiffen and ankylose. This retention of the most valuable part of finger movements, because being valuable they are the last to be given up, shows I think that movement is more an advantage than a disadvantage in the treatment of chronic arthritis.

But even if one allows that an infective arthritis should only be rested until the patient has acquired some sort of immunity, one must agree that at times the pain is so great that the patient will not move the joint. Under these circumstances the muscles immobilise the joint, but unfortunately they do not immobilise the joint in the best position. And the doctor is forced to apply a splint not in order to immobilise the joint but in order to hold it in the best position for function. What is the best position for function? In a weight-bearing joint there is do doubt that this is the *position of minimal effort*. This term needs defining. The amount of energy spent by the muscles in holding the erect position is small because all the muscles have to do is to balance the joints so that body-weight passes directly down through the centres of the joints. The muscles then act like the stay-wires of a wireless mast. The position in which weight passes directly down through the centre of a joint is conveniently called the position of minimal effort. This position varies with different joints. In the hip it is full extension with slight abduction, the position the hip naturally takes up when a person

stands on one leg. One can easily convince oneself by palpating the gluteus maximus that the antigravity muscles are not in vigorous action when a person is standing. Likewise, if a person is struck unexpectedly on the back of the knee when standing his knee collapses, showing that the quadriceps was not hard in action.

If a joint cannot be put into the position of minimal effort the muscles expend a vast amount of energy holding the erect position. So that, however much the range of movement of a joint dwindles, the position of minimal effort must be maintained or if lost must be regained. Fixed flexion of the knee is common with chronic arthritis, and the position of minimal effort—full extension—can and must be regained by a forcible manipulation under anaesthesia. The manipulation ruptures the ligament at the back of the knee. Lest a violent reaction follow—which oddly enough rarely happens—the knee after the manipulation is held in full extension by a plaster back-splint which includes the foot. Next morning the bandages are removed and the patient is encouraged to bend the knee. It is surprising how much the patient is able to flex the knee considering the brutal exertions of the surgeon of the day before. After being exercised the knee is again bandaged into the plaster back-splint. The exercises are repeated several times a day and in the intervals the patient is encouraged to lift the leg off the bed, the knee being held straight by the plaster. As the quadriceps gains in strength the plaster is left off for longer and longer periods in the day until finally when the patient can hold the knee fully extended against resistance the splint is discarded.

I would have you note two things. First, that by this line of treatment a severe injury is inflicted on the knee joint and that injury is treated immediately by activity; and second, that even in the important task of maintaining the position of minimal effort splintage should only be intermittent. I submit that there is no place for continuous splintage in the treatment of infective arthritis except perhaps for joints where ankylosis causes little disability, such as the wrist joint.

SOFT-PART INJURIES

When a person has, as he thinks, sprained a joint he may have sustained one of three soft-part injuries. He may have torn a muscle, he may have sprained a joint or he may have strained a joint. In as much as treatment and prognosis of these three injuries are different it behoves us to make an accurate diagnosis.

After a tear of muscle, movement remains painful for a time and the patient is grateful if the joint is splinted. Splintage after this injury does no harm provided that the muscle is not allowed to remain idle. If the muscle does remain idle the repair tissue binds together the unharmed muscle fibres so that when they are called upon again to contract pain is felt on account of adhesions. Thus, in the common injury of the calf, so pleasantly but inaccurately called a ruptured plantaris, it is permissible to splint the ankle by a bandage or by strapping so as to make walking easier, but at the same time the calf muscles should be treated with faradism.

The second injury to consider is a sprain. There is considerable misunderstanding about how a ligament works. Its apparent task is to restrict movement at a joint. But the inherent strength of a ligament is small. It does its work by proxy and it makes use of the muscles for the purpose. When a joint is moved by an external force the ligaments are put on the stretch. As soon as a ligament is put on the stretch the overlying muscle is reflexly stimulated to activity. It contracts and resists the force, and the underlying ligament escapes harm. Thus in the ordinary way muscles protect ligaments. They may however fail in their duty. First, the muscles may be caught off their guard, as happens when one is walking on uneven ground in the dark and twists an ankle; and second, the force may be too great either in time or in intensity for the muscles to support, as happens when one stands for long after an illness in bed. Under these circumstances the ligaments lose their protection and then they have themselves to oppose the force; and this they have not the strength to do. If the force is

sudden the ligament tears macroscopically. We call this injury a sprain. If the force is moderate but prolonged the ligament tears microscopically. We call this injury a strain.

There are in existence muscles to prevent a joint from being moved beyond a certain range in all directions in which a joint normally moves, but there are no muscles to prevent movement in a direction in which the joint does not normally move. There are therefore two kinds of sprain. One caused by excessive movement in a normal direction, and the other caused by movement in an abnormal direction. A sprained ankle (which should of course be called a sprain of the subtalar joint since it is caused by excessive inversion of the foot) is an example of the first kind of sprain, and an injury of a finger joint an example of the second kind of sprain.

After a sprain of the subtalar joint active movements may be allowed at once, for there are muscles available that will reflexly come into action if the ligament is threatened. No harmful force can fall on the ligament while it is repairing.

With a sprain of an interphalangeal joint there are no muscles to prevent a lateral hinge—the force probably responsible for the injury—and movement in this direction must

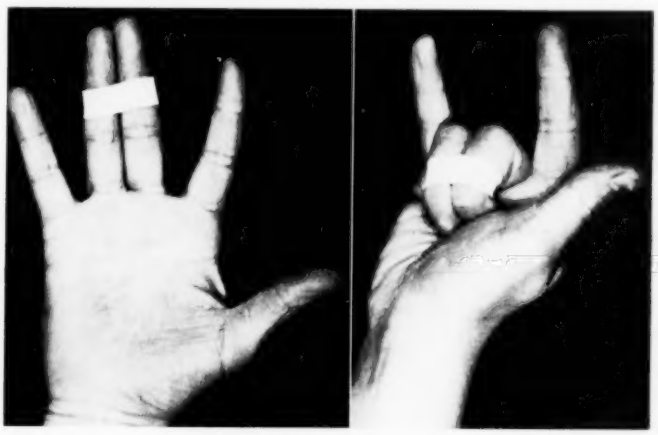

FIG. 1
Garter splintage for sprained interphalangeal joint.

be prevented while the ligament is undergoing repair. This is most easily done by binding the injured finger to its neighbour by means of a miniature garter (Fig. 1). This affords the necessary protection and at the same time allows both fingers to flex and extend fully. This illustrates well the principle of treatment of this kind of sprain, namely the prevention of abnormal movement without restriction of normal movement.

When a ligament has been torn the joint should not be immobilised if it can be avoided. For consider what happens after the injury. The torn ends of the ligaments are bathed in fluid which has exuded from the capillaries. The exudate clots, the clot becomes organised, and finally turns into scar which binds together everything in the neighbourhood. If the joint has been kept still while this is happening movements are afterwards impeded by painful adhesions, which have to be stretched or broken before painless movement is restored. The general practitioner is well aware of the patient who complains bitterly of a painful foot after a sprain. The patient haunts his surgery for weeks until finally in despair he goes to a bone-setter who cures him by restoring movements that would never have been lost had the foot not been immobilised.

The third soft-part injury to consider is a strain. A ligament tears microscopically—that is, it is strained—when a force greater than its muscles can withstand is exerted on the

joint for some time. The indications for treatment are clear: to withdraw the force until the ligament has recovered and in the meanwhile to strengthen the muscles so that in future they will be strong enough to sustain the force. Since the force is usually body-weight, withdrawing the force implies recumbency.

Thus it comes about that a sprain is treated by movement, and a strain by recumbency.

DISLOCATIONS

A dislocation is but one stage further than a sprain, and should, I think, be treated in the same way. But whereas many surgeons are willing to allow early movements after a sprain, most are in favour of splinting a joint after a dislocation. They argue that rest lessens the risk of complications. Complications after a sprain are few, but after a dislocation three that might be influenced by early movements are common: aseptic necrosis, recurrent displacement and myositis ossificans.

Aseptic necrosis is seen most often at the hip joint. It is a deceitful process because it does not reveal itself immediately. There is nothing to tell that the blood supply to the femoral head has been impaired until a radiograph taken several months later shows increased density of the head. This stage is likely to be missed because the patient has apparently recovered and has been discharged and probably lost sight of. Over the next year or two the head of the femur gradually deforms as a result of the softening unavoidably associated with the removal and replacement of the dead bone. The patient then presents himself again complaining of pain.

It is difficult to see how immobilising a joint after a dislocation can avert aseptic necrosis, for the damage to the arterial supply is surely done at the time of the accident. Avoidance of weight bearing prolonged over several years might prevent deformation of the head, but no patient can afford so long a period of invalidism. Aseptic necrosis is uncommon except at the hip and no one knows what influence immediate treatment has, or what are the relative merits of plaster fixation, recumbency and early weight bearing. My own plan is to keep the patient in bed until he has regained muscular control over the joint and can raise the leg off the bed with the knee straight and rotate it in mid air. He is then got up on two sticks and the sticks are discarded as soon as he can stand on the affected leg without exhibiting a Trendelenburg pelvic tilt.

The second complication—recurrent displacement—happens after two injuries: anterior dislocation of the shoulder and inversion-subluxation of the ankle. A dislocation of the shoulder recurs, it is supposed, because the glenoid rim, on account of its poor blood supply, has difficulty in reattaching itself to the bone of the scapula. It is reasonable therefore to hold the torn structures in apposition for a time by keeping the arm adducted and medially rotated. Whether this does in fact reduce the incidence of recurrence is not known. Also, it is debatable whether it is right to impose a longer period of disability on every patient in order to save a few from a recurrence of their dislocation. For there seems no doubt that splinting does prolong convalescence. If movements are unrestricted and encouraged from the start a patient with an uncomplicated dislocation of the shoulder is using his arm naturally again within a week. The figures of De Marlaix are instructive. He found that if the shoulder was not immobilised at all after a dislocation the patient recovered on an average in eighteen days; if the joint was immobilised for one week recovery took fifty-two days; if for two weeks 121 days; and if for three weeks 300 days.

The other dislocation liable to recurrence is inversion-subluxation of the ankle. This is often confused with a sprain of the subtalar joint, and I doubt whether it is possible to distinguish them clinically. One can of course distinguish them by radiographing the foot in forced inversion, but after an injury that is only possible under anaesthesia. In Figures 2 and 3 both feet have been fully inverted. In Figure 2 movement has taken place at the

subtalar joint, and if the movement continued the patient would suffer a sprain of the subtalar joint; in Figure 3 movement has taken place at the ankle. This happens repeatedly, and the patient complains that his ankle is constantly going over in spite of all his efforts by muscular action to prevent it.

Sprain of the subtalar joint is common, but recurrence is rare; so it is hardly worth while submitting every patient to a radiographic examination under anaesthesia in order to find the occasional case of inversion-subluxation. Moreover it is doubtful whether an inversion-subluxation of the ankle can be prevented from recurring by immobilisation, however prolonged. It is better, I think, to treat all *first* sprains of the ankle region with early movements. Patients who complain of repeatedly turning over their ankles are probably suffering from inversion-subluxation, and the diagnosis can be confirmed by radiographing the foot in forced inversion during a quiet period. The subluxation can be cured by an

FIG. 2

FIG. 3

Radiographs of both feet in forced inversion. In Figure 2 the movement has taken place at the subtalar joint, but in Figure 3 it has occurred at the ankle joint.

operation at which a peroneal tendon is threaded through the talus. This effectively prevents the talus from tilting in the mortise, and the patient is off work no longer than he would have been after the original accident if the foot had then been immobilised in plaster.

The third complication—myositis ossificans—occasionally follows a dislocation. The etiology is not known. There is no evidence to show that myositis ossificans is made worse by active exercises. I stress the word active. Characteristically, myositis ossificans is accompanied by spasm of the muscles controlling the joint. Let it be granted that forced movements, and I would include in this category movements masquerading as passive, may do harm, but such movement as the spasm allows probably does no harm. I do not believe that the advice of Sir Robert Jones that in cases of myositis ossificans the joint must be rigidly splinted need be followed. Such movement as the patient permits himself to make is harmless.

FRACTURES OF THE SHAFT

There is a wide divergence of opinion on the principles that should govern the treatment of a fracture of the shaft. We are told on very good authority that the fundamental treatment of a fracture is prolonged uninterrupted immobilisation. This fits in with the patient's idea of things, for he believes that every fracture needs "setting" and after that "splinting."

It is not my purpose in this paper to discuss the necessity or otherwise of setting a fracture. What I am concerned with here is the advisability of splintage.

It is not generally realised that a splint is used for two entirely different purposes. More commonly it is used to preserve alignment, as in a fracture of the shaft of the femur. It may also be needed—and my contention is that the need rarely arises—to obtain union by bone.

FIG. 4
Fracture of humerus before treatment.

FIG. 5
Radiograph sixteen months later. No splintage was used except that provided by a sling. Active shoulder and elbow exercises were encouraged from the beginning.

All structures in the body when divided tend to join. The uniting bond is usually fibrous. This is because the repair tissue is under tension; it is being pulled apart all the time. When the repair tissue is compressed the uniting bond becomes bony. In fractures of the shaft there are muscles attached to both fragments capable of compressing the bone ends against one another, so that union will be by bone even in the absence of splintage.

Figure 4 shows the radiograph of a fracture of the uppermost fourth of the humerus. The displacement is seen better in the lateral view. The fracture was not reduced. The patient was treated with his arm in a sling, and no other splint was used. Active movements of all joints of the arm including those of the shoulder were encouraged from the start. Figure 5 is the radiograph sixteen months later. At that time he had normal function of the shoulder. A possible criticism is that I have chosen as an example a fracture that is known not to give any trouble over union. So I have included another: a transverse fracture of the shaft of the humerus (Fig. 6)—a fracture of ill-repute which often does not join by bone. The patient was treated in the same way. The arm was supported in a sling and no other splint was used. Movements at the shoulder were not encouraged to start with, for they would have caused the fracture to hinge. But when joints distal to the shoulder are moved all the muscles overlying the fracture are simultaneously in action, and they compress rather than hinge the site of the fracture. It was safe therefore to allow movements of the fingers, wrist, forearm

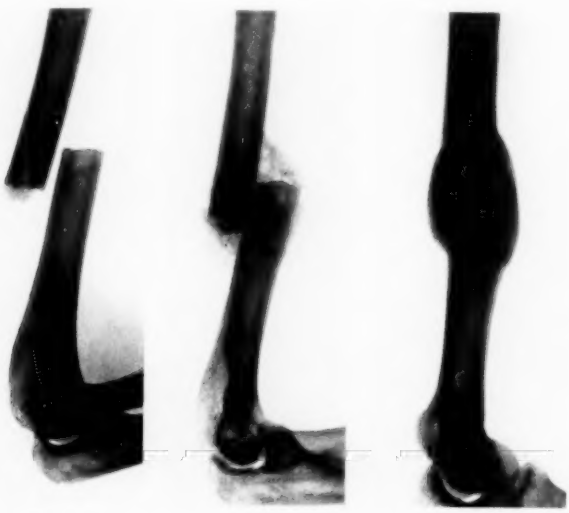

FIG. 6 FIG. 7 FIG. 8

Fractured shaft of humerus treated by a sling without other splintage. Elbow movements were encouraged from the beginning. Figure 6—Initial radiograph. Figure 7—Two and a half weeks later. Figure 8—Three months after injury.

and elbow. Figure 7 shows the state of union two and a half weeks after the injury, and Figure 8 his final radiograph three months after the accident.

A further example is that of a fractured femur. The femur was plated, and the leg was encased in a long plaster spica. Ten months after the accident, soon after he had started weight bearing, he suddenly felt a pain in his thigh and was unable to put his foot on the ground. The radiograph shown in Figure 9 was taken at that time. I gave him an anaesthetic and forcibly straightened the leg, put on a cylinder of plaster to maintain alignment and got him up walking. Figure 10 shows the degree of union after ten weeks when the plaster was discarded, and all treatment ceased. Figure 11 was taken at a routine follow-up one year later. It shows that union has gone on to consolidation. These pictures to me tell a story. The story they tell me is that when the bone was rigidly immobilised by a plate and the muscles put out of action by a long spica plaster the amount of callus was small, but as soon as the plate had broken and the fractured ends could be compressed by muscle action and by weight bearing, the fracture promptly united.

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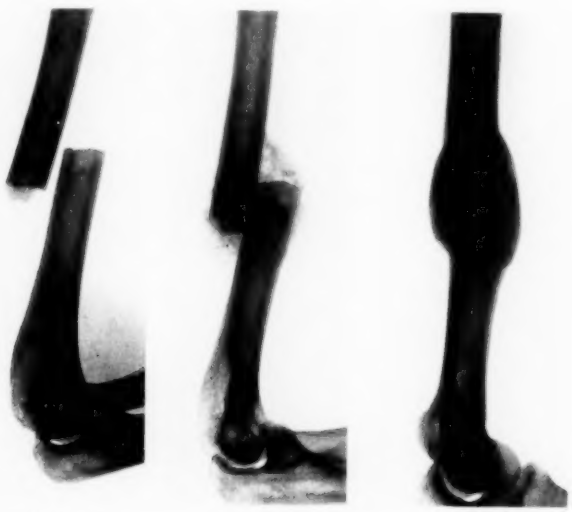

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These illustrations show that rigid immobilisation is not, at any rate in every case, essential for bony union. But I go further, for I maintain that splintage is only essential for bony union when there are no muscles attached to the fragments capable of impacting the bone ends. When we come to consider which these fractures are, we find that they are only three: fractures of the carpal scaphoid, transcervical fracture of the neck of the femur, and a fracture of the medial malleolus. Splintage may be needed to hold the fragments in alignment, but that is beside the point.

Teaching that splintage is not always essential is dangerous for a student up for an examination because there are fractures that must be splinted in order to obtain union by bone. Whenever there are no muscles attached to the fragments capable of impacting the bone ends sheering and hinging stresses at the fracture line must be prevented by splintage. Teaching the reverse, that every fracture requires rigid immobilisation, may not be as dangerous for the student but it is equally harmful for the patient, for under a splint muscles lose their

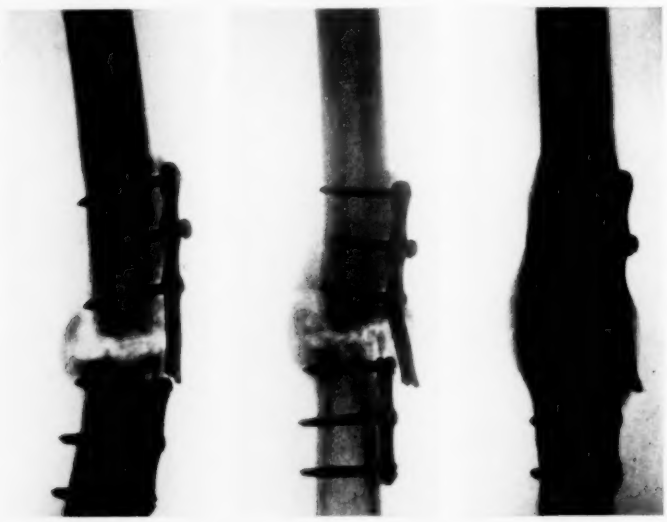

FIG. 9 FIG. 10 FIG. 11

Figure 9—Fracture of femur ten months after plating: the plate has broken and the fracture is ununited. Walking was encouraged in a plaster cylinder. Figure 10—Condition ten weeks later when the plaster was discarded. Figure 11—One year later.

extensibility and joints seize up, and under favourable circumstances it is weeks before free movement returns, and in less favourable cases full movement may never be regained. The patient with the fractured femur illustrated in Figures 9 to 11 never got back more than about 15 degrees of movement at his knee. Be it noted that this loss was caused by treatment.

So important is movement that one is tempted nowadays, with the risk of sepsis almost eliminated by antibiotics, to use an internal splint to preserve alignment in order to allow early movement. This principle is well illustrated in fractures of the tibia and fibula where it is sometimes possible by plating the tibia to dispense altogether with an external splint. The radiograph shown in Figure 12 was taken immediately after the plating of a tibia. Figure 13 shows the range of ankle movement three weeks from the accident. The patient returned to his former work as a labourer three months after the accident. In this case, as always, encouraging activity of the muscles overlying the fracture hastened repair. Note that the internal splint was used, not to immobilise the fragments, but to allow the joints to move freely from the beginning of treatment.

Fig. 12

Fig. 13

Figure 12—Fractured tibia, plated to permit early joint movements.
Figure 13—Range of movement three weeks after the injury.

Fig. 14

Fig. 15

Figure 14—Fractures of four metatarsals. Reduction not attempted and no splintage used. Rapid recovery of function. Figure 15—Fractures of several metatarsals. Reduction not attempted and no splintage used. Normal function within six weeks.

FRACTURES THAT CANNOT BE REDUCED

Splints are used for two purposes. Rarely, they are needed to prevent hinging and sheering stresses at the site of the fracture, so that the uniting bond shall be bony and not fibrous. More commonly, they are used to hold the bone ends in good position—that is, to maintain reduction once it has been obtained.

What if reduction cannot be obtained? When a fracture cannot be reduced it is futile (apart from being harmful) to enclose the limb in plaster when the sole object of the plaster is to hold reduction. If any patient with a Bennett's fracture taken at random and wearing a plaster splint with a wire gallows and elastic tractions were radiographed I am willing to wager that in nine cases out of ten the radiograph would show that the fracture was not reduced. It is clearly absurd to impede movement by a splint that is serving no useful purpose. I submit that when there is no displacement, and when reduction cannot be obtained or maintained, the fracture is better not splinted. Figure 14 is the radiograph of a foot showing fractures of four metatarsals. Displacement was slight, so reduction was not attempted. No splint was used. The patient was got up and taught to walk. The bones were able to look after themselves and while they were uniting stiffness of the toe and tarsal joints was avoided by active use of the foot. Had this patient been treated in plaster I believe it would have been months before he was at work again manhandling heavy loads of paper. Figure 15 is another example. Reduction was not attempted and no splint was used. A wound of the skin was sewn up and before that was healed the patient was up walking. He returned to his work as a sailor in six weeks believing that he had a normal foot. Perhaps he had.

FRACTURES INVOLVING JOINTS

Fractures involving joints present problems distinct from those of a fracture of the shaft. The joint may be injured in several ways, each one calling for its own treatment.

First, a fracture of the shaft may extend into the joint without causing any displacement. Involvement of the joint in this type of fracture is of no moment. The fracture is treated as a fracture of the shaft and the joint injury is disregarded. This injury is caused by a vertical force ascending the shaft, and the usual history is a fall from a height, the patient landing on his feet. Often there is a fracture of the calcaneum on the same or the opposite side (Fig. 16). The interesting thing about the fracture is that the patient can be got up weight bearing straight away; for, a fracture that is not displaced by an initial force composed of body-weight plus momentum will not be displaced by body-weight alone.

FIG. 16

Vertical fracture involving the articular surface of the tibia; immediate weight bearing can be begun. There is a fracture of the calcaneum on the opposite side.

In the second variety of intra-articular fracture there is separation and displacement of part of the articular surface. One of two things may happen to the fragment. It may be depressed

below the level of the articular platform; in this case if the fragment is not replaced the overall bearing surface is reduced. Or it may project above the level of the articular platform; in this case if the fragment is not replaced the opposing articular surfaces become incongruous.

A depressed fragment is difficult to elevate to its proper level except at open operation and almost impossible to retain in position without internal fixation. This is common knowledge. What is not so well recognised is that unless reduction is exact it might just as well not have been attempted. Figure 17 is the lateral view of a lateral-rotation Pott's fracture; it shows a large posterior tibial fragment which has been screwed to the back of the shaft of the tibia. Unfortunately reduction is not complete and no benefit has been derived from that part of the operation; for the fragment is still below the level of the articular surface and can take no part in the transmission of weight.

FIG. 17

Internal fixation for fracture of posterior articular margin of tibia with large displaced fragment. Reduction is not exact and might as well not have been attempted.

This case is unusual in that the separated fragment is large. If it were not replaced, a third or more of the bearing surface would be lost. It was therefore reasonable to attempt reduction. But as a rule the fragment is small, and the remaining intact part of the bearing surface is sufficient to transmit weight. So that, considering how difficult it is to do, it is hardly worth while attempting to reduce a depressed fragment unless it is very large. If reduction is not to be attempted splintage is of course superfluous and active movements can be started at once.

A depressed fragment has not any natural inclination to return to its bed. But in the case of an elevated fragment, if the joint is made to move, the opposing articular surfaces will press the fragment back into position and mould the articular surface to conform to its own shape. Here is a clear indication for early movement. But there is another reason why this type of intra-articular fracture should be treated with early movement. If the joint is immobilised the damaged capsule, infiltrated as it must be with repair tissue, will shorten unless it is kept at full length while the repair tissue is being converted into scar. I would submit that an intra-articular fracture of this sort should be treated by early movements and not by rest, in order, first, to flatten any bony excrescences projecting from the articular surface and, secondly, to prevent loss of movement at the joint.

Three common injuries illustrate this principle of treatment: the fracture of the lateral condyle of the tibia—the bumper fracture; the T-shaped fracture at the lower end of the humerus into the elbow joint; and the T-shaped fracture of the lower end of the tibia into the ankle.

In the bumper fracture the lateral part of the articular surface is smashed. The fractured portion may be displaced laterally, it may be depressed, or it may be comminuted. No matter which of these has happened treatment is the same. Traction is applied to the leg and active movements of the knee are started on the day after the accident. Skeletal traction is more comfortable than skin traction, because it can be applied low down in the tibia, far away from the site of injury. It has the additional advantage that it does not impede movement.

Fig. 18

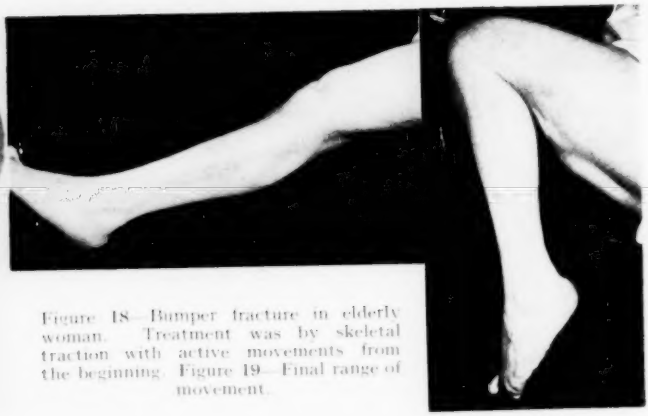

Figure 18.—Bumper fracture in elderly woman. Treatment was by skeletal traction with active movements from the beginning. Figure 19.—Final range of movement.

Fig. 19

Fig. 20

Comminuted T-shaped fracture of the lower end of the humerus. Treatment was by collar-and-cuff sling, with immediate active movements.

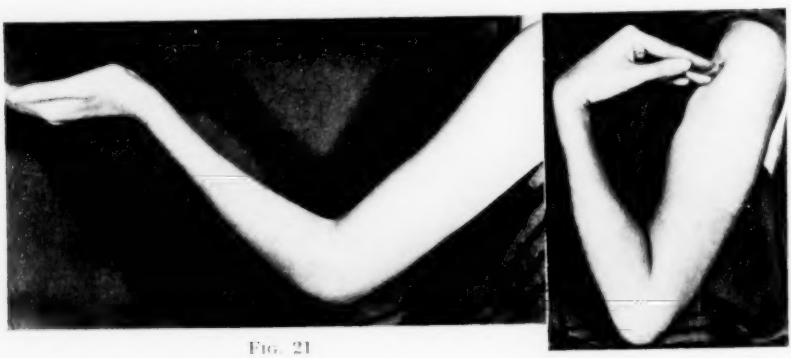

Fig. 21

Final range of movement.

Figure 18 illustrates a typical bumper fracture in a woman of sixty-two. The radiograph eighteen months later showed some genu valgum. The genu valgum is permanent but this deformity does not cause any disability and the cosmetic effect can be disregarded in patients of this age. Figure 19 shows the range of movement obtained by this patient. I have never seen results so good as these after the more orthodox method of treatment, namely immobilisation in plaster.

Figure 20 shows a T-shaped fracture of the lower end of the humerus. In this patient the wrist was slung to the neck, and no other splintage was used. Active movements of the elbow were started at once. Gravity and movement were relied upon to reduce the

Fig. 22

Fig. 23

Figure 22—Displaced fracture of capitulum. Treatment was by open reduction followed by immediate active movements. Figure 23—Range of movement after three weeks.

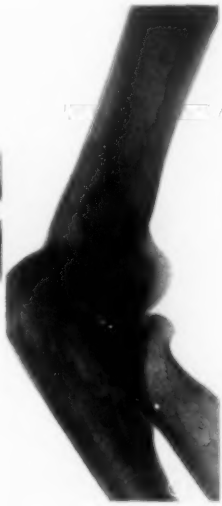

Fig. 23

displacements. Figure 21 shows the range of movement she regained. Extension is far from full, but luckily at the elbow more is not required. This is not a good result, but I do not think any other treatment would have given a better.

In the third variety of intra-articular fracture the whole or almost the whole of the articular surface breaks away from the shaft, and there is nothing, neither ligament nor muscle, attached to the fragment. Such a fracture is by no means uncommon at the elbow—the so-called fractured capitulum (Fig. 22). The fragment is displaced forwards and upwards. It can be replaced by digital pressure under direct vision after the joint has been opened. The problem is what to do after the fragment has been replaced. I believe that active movements of the elbow should be allowed at once. Repeated movement causes the humeral fragment to settle into its correct position *vis-à-vis* the ulna so that when it has become reattached to the shaft the opposing articular surfaces of the humerus and ulna fit one another. Figure 23 shows the range of movement at the end of three weeks. Movement gradually increases.

The fourth and last variety of intra-articular fracture is that in which a fracture is associated with a subluxation or a dislocation of a nearby joint. Figure 24 shows an unusual fracture of this kind. It was treated as though it were a bumper fracture. Traction was applied to the leg and active movements of the knee were begun immediately. Figure 25 is the radiograph five months later. Figure 26 shows treatment in progress. The use of narrow fracture boards enables half the mattress to be let down so that the patient can exercise the knee.

Most Pott's fractures fall into this group. We are here dealing with a dual injury a fracture of a bone and a subluxation of a joint. Of the two injuries the more important is

FIG. 24

FIG. 25

Figure 24—Fracture-dislocation of the knee. Treatment was by traction and immediate active movements. Figure 25—Condition five months later.

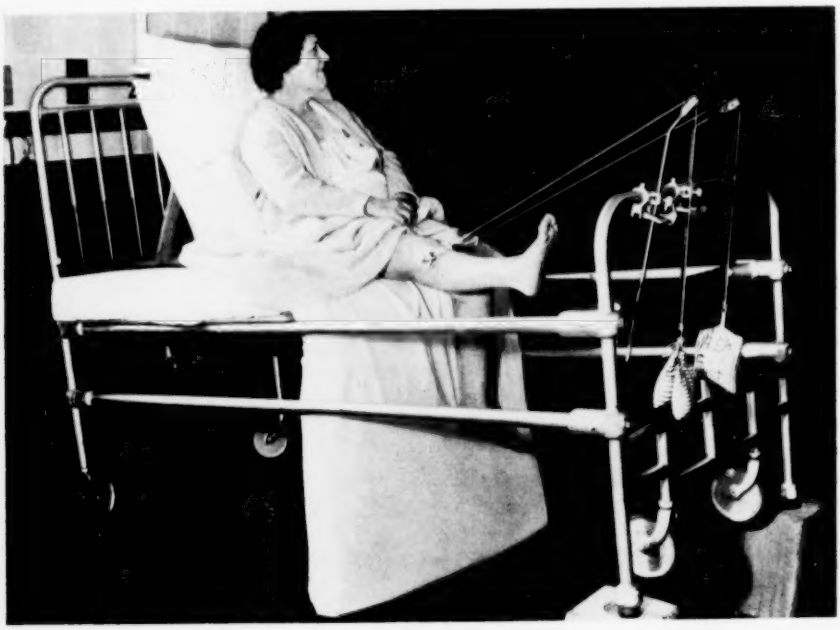

FIG. 26

Treatment in progress. The use of narrow fracture boards enables half the mattress to be let down so that the patient can exercise the knee.

the subluxation. Indeed, it is the only one that need be treated because if the talus is in position the fracture or fractures are automatically in good alignment. In every Pott's

fracture we need to know, not the alignment of the fractures, but whether the talus is out of position. Figure 27 shows a lateral-rotation Pott's fracture with displacement of the talus. The displacement is not great but it must be reduced because in its present position the talus does not fit the articular surface of the tibia. This being a lateral-rotation fracture, the talus slips back into position when the foot is medially rotated (Fig. 28). If the talus has had to be replaced, it must be held in position. This is usually done by an external splint, and the leg

FIG. 27

FIG. 28

Figure 27—Lateral rotation fracture of the ankle with slight but important displacement of the talus. Figure 28—Position after reduction by medial rotation.

FIG. 29

FIG. 30

Figure 29—Lateral rotation fracture of the ankle with displacement of the talus. Figure 30—Stabilisation of the fracture, by internal fixation of the medial malleolus, enabled early active movements to be begun.

is encased in plaster from the toes to just below the knee. In order to hold the talus in position it has been necessary to immobilise the ankle, although immobilisation is not necessary for the repair of the bone. If it were possible to hold the talus back in position and still allow movement at the ankle, that would be preferable. Luckily there is a method of doing this. Anatomically the talus is firmly attached to the medial malleolus by a ligament. If, therefore, the medial malleolus is fixed to the shaft of the tibia with a screw the talus is automatically

anchored. Figure 29 shows an ordinary lateral-rotation Pott's fracture with a lateral shift and a lateral tilt. The medial malleolus was screwed to the shaft and the talus went back in position (Fig. 30). External splintage was dispensed with.

The method has even greater merit in the abduction type of Pott's fracture (Fig. 31), which in the ordinary way has to be splinted for a long time if secondary malunion is to be avoided. In this patient, as in the last, the medial malleolus was screwed to the shaft of the tibia. No external splintage was employed. The radiograph shown in Figure 32 was taken six weeks after the injury, when the patient was about to return to work.

I would draw your attention to the purpose for which internal fixation has been used in these fractures. It was used in order to dispense with external splintage so that movement could be started at once. The disability after a fracture rarely is the fault of the bone. It is nearly always related to loss of movement, and this loss of movement is caused by

FIG. 31

FIG. 32

Figure 31—Abduction fracture of the ankle with displacement of talus. Figure 32—Condition six weeks after injury. Good function had been restored by active movements from the beginning.

immobilisation. The earlier the joints are moved after a fracture, the quicker a man returns to work and the less his ultimate disability. The doctor who treats a fracture should all the time be asking himself: How much stiffness will this patient be left with?

FRACTURES OF THE PELVIS

It is high time that the bogy of the fractured pelvis was laid to rest. A fractured pelvis is a serious injury by reason of its two complications: paralytic ileus and rupture of the urethra. But, *qua* fracture, the injury is trivial. Splintage is rarely required and early weight bearing is well tolerated. Figure 33 shows a disruption of the pelvic ring. There is a fracture through the ischium on one side and through the pubis on the other. In the treatment of this patient the teaching of John Hilton was disregarded; although he had pain he was not treated by rest. Figure 34 shows the patient standing on the worse side three weeks after the injury. He also had a crush fracture of a vertebral body; Figure 35 shows him bending and touching his toes three weeks after the injury. Incidentally he had a dislocation of the elbow with a comminuted fracture of the head of the radius. He has not yet, as may be seen in Figure 35, quite recovered full extension of his elbow.

FIG. 33

Fractured pelvis involving the ischium on one side and the pubis on the other. Early weight bearing was permitted. The patient also sustained crush fracture of the lumbar spine and comminuted fracture of the head of the right radius.

FIG. 34

FIG. 35

Figure 34—Showing ability to stand on the worse side three weeks after the injury. Figure 35—Showing range of spinal flexion three weeks after the injury.

CONCLUSION

I have tried to stimulate interest in movement as a method of treatment. It is too much to expect that I shall have won over to my way of thinking doctors who are addicts of rest. I shall be content if they will occasionally ask: " Is my splint really necessary ? "

EARLY TREATMENT OF PARAPLEGIA FROM FRACTURES OF THE THORACO-LUMBAR SPINE

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This paper concerns only the immediate treatment of paraplegia from fracture-dislocations of the spine at the thoraco-lumbar level. It is based on experience gained in the treatment of sixty-eight patients of whom forty-seven were treated by us from the beginning and twenty-one were admitted to the paraplegic centre several weeks or months after injury. From this experience we have reached certain conclusions about the immediate treatment of thoraco-lumbar injuries, developing as evidence accumulated, so that some patients seen in earlier years were not treated as they would be now. In this series there are so many varied factors that we have made no attempt to present our observations statistically.

Most paraplegic patients die as a result of large bed sores and urinary tract infection, many of them as the result of inefficient treatment. Moreover, bad initial treatment results in a host of other complications such as gross angulation of the spine, stiffness of joints, contractures and deformities, which seriously delay or even prevent late rehabilitation. Early treatment must be designed to prevent these complications, to assist the establishment of compensatory mechanisms, and to promote every possible recovery of nerve function.

ANATOMY OF THE SPINAL CORD AND NERVE ROOTS

In this study, the relationship of the vertebral column to the spinal cord and nerve roots at the thoraco-lumbar level is fundamental (Fig. 1). The tip of the spinal cord lies opposite the lower border of the first lumbar vertebra. Opposite the junction of the twelfth thoracic and first lumbar vertebrae lie the first and second sacral segments of the cord; while all the lumbar cord segments are situated at a higher level, probably extending as high as the ninth thoracic vertebra. Thus all the lumbar roots arise from the cord above the thoraco-lumbar junction, at which level they lie side by side with the upper sacral segments of the cord. Thus at the thoraco-lumbar junction there are two types of nerve tissue supplying the lower trunk and legs, namely the cord which is very susceptible to injury and incapable of regeneration, and the lumbar nerve roots which are more tolerant of injury and in certain circumstances may be capable of regeneration.

In most patients in this series the injury was severe enough to cause irrecoverable damage to the spinal cord but insufficient to cause irreparable damage to the nerve roots at that level, so that neurological examination of many patients showed that at least some lumbar roots had escaped injury. This finding has been confirmed at operation, by post-mortem examination, and by subsequent histological section of the cord and nerve roots. We refer to it as "root escape."

Classification of thoraco-lumbar nerve injuries—Nerve injuries at the thoraco-lumbar junction may therefore be divided into three main groups: 1) complete division of the sacral cord and all lumbar roots; 2) complete division of the sacral cord with escape of nerve roots on one or both sides; 3) incomplete division of the sacral cord with escape of nerve roots.

Effects of cord section—If the spinal cord is divided at the first sacral segment or immediately above it, there will be complete loss of voluntary power and loss of sensation in all parts supplied by the sacral segments, together with isolated reflex activity of these segments as indicated by reflex bladder and bowel action, presence of the bulbo-cavernosus and anal skin reflexes, and sometimes of extensor plantar responses. Full reflex activity is not established

until some weeks after injury but, in many cases, the bulbo-cavernosus and anal skin reflexes return within a few hours and this, together with complete paralysis and anaesthesia of the sacral segmental supply, indicates transection of the cord.

Significance of lumbar root escape.—The lumbar roots control flexion and adduction of the hips and extension of the knees; they contribute to the control of extension and abduction of the hips, flexion of the knees, and dorsiflexion of the foot; and they are responsible for much of the sensation of the leg (Figs. 1 and 2). Division of the roots causes loss of these movements and of this sensation. Thus, the clinical picture of complete cord and root division at the thoraco-lumbar junction is that of complete paralysis and anaesthesia below the L.1 segment, together with the return of isolated sacral reflexes but not of the lumbar reflexes.

Full root escape on either side is shown by the presence of reasonably good flexion and

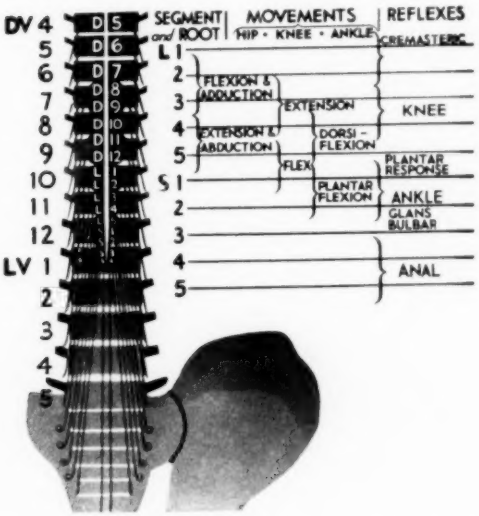

FIG. 1

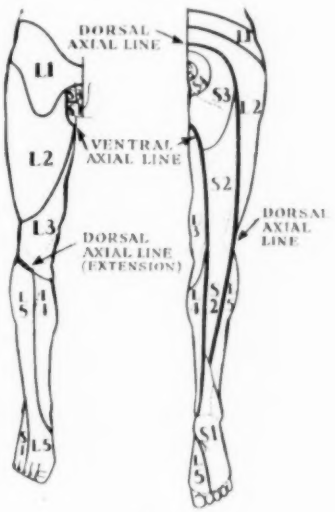

FIG. 2

Figure 1.—Diagram showing the relation of the vertebrae to the segments of the spinal cord. Opposite the twelfth thoracic vertebra lie the upper sacral segments and all the lumbar roots. Injury at this level will divide the cord and all the lumbar roots and is therefore a mixed cord and root injury. The segmental control of leg movements and reflexes is also shown. Figure 2.—The lumbar and sacral dermatomes.

adduction movement of the hips with weak extension and abduction movement, good extension and weak flexion of the knees, and weak dorsiflexion of the ankles, but with no plantar flexion of the foot or movement of the toes. Cutaneous sensation to pinprick and cotton wool are present in the lumbar dermatomes, and the knee jerks are present.

Many variations of this clinical picture may occur, depending on the number of nerve roots that have escaped damage and on the degree of injury to the spinal cord; but it cannot be emphasised too strongly that in injuries at this level the presence of voluntary activity in the lumbar segments is evidence not of an incomplete cord lesion but of root escape. Only the presence of voluntary activity in the sacral segments is evidence of an incomplete cord lesion.

Of the sixty-eight patients in this series with paraplegia sustained at the thoraco-lumbar level, thirty-three had complete cord and root lesions, and thirty-five had cord lesions with root escape on one or both sides. Of the thirty-five patients with root escape, twenty had

complete physiological isolation of the sacral cord with some bilateral root escape, seven had similar cord injury with unilateral root escape, and eight had incomplete cord damage with complete root escape.

The function of the lumbar roots is of the very greatest importance. Without the function provided by lumbar roots, the balance and stability of the lower limbs and trunk are seriously

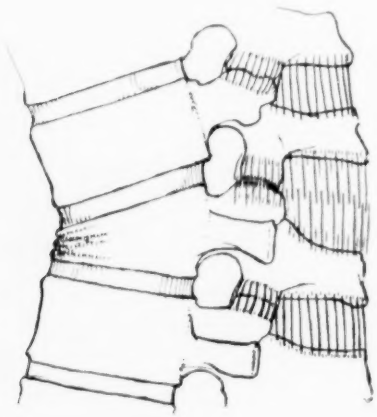

FIG. 3

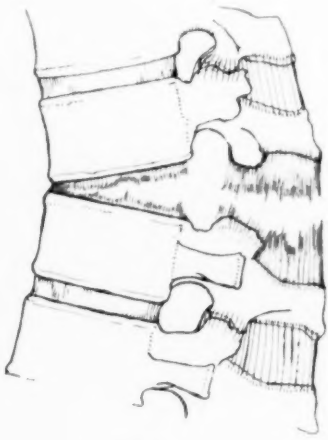

FIG. 4

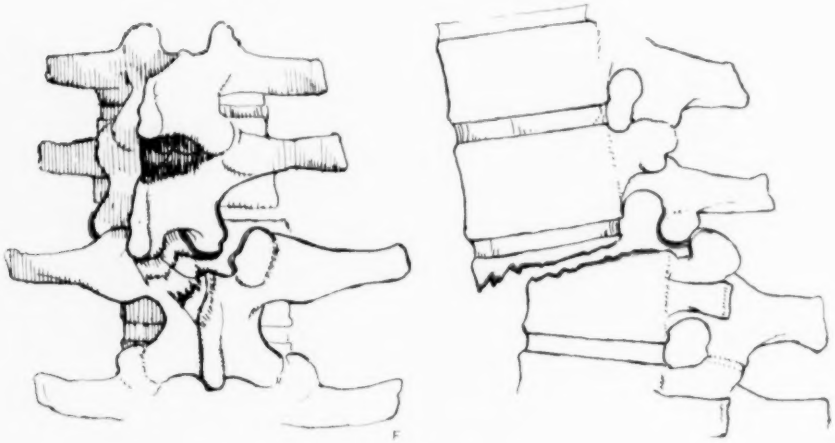

FIG. 5

The mechanism of the thoraco-lumbar fracture and fracture-dislocation. Figure 3—The ligaments remain intact and the forces are expended on the body, producing a stable crush fracture. There is little deformity of the spinal canal. Figure 4—The ligaments rupture and with flexion violence a pure dislocation is produced. Figure 5—Torsional violence with rupture of the ligaments and fracture of the articular processes produces rotation and the typical "slice" fracture of the body. This fracture-dislocation is unstable

impaired and walking in caliper splints is far from easy. With such function there is much better muscle control, and mobility is greatly increased. If the lumbar nerve roots are undamaged many patients do not require full-length calipers. Even the escape of one or two roots on either side can determine the possibility of the patient taking steps by using the hip flexors instead of merely swinging the legs by pelvic tilting. It is therefore essential

that a careful neurological examination be made to correlate the neurological level with the fracture level and thus to differentiate between cord and root injury, for even with initial complete paraplegia it is our experience that whereas the cord never recovers the roots sometimes do.

Mechanics of injury to the vertebral column—Fracture-dislocations of the spine with severe cord and root damage are sustained only as the result of considerable violence; and yet many patients with complete paraplegia have shown only slight vertebral displacement whereas others, with gross shift, have shown no neurological damage. This was puzzling until it was realised that displacements seen on radiographic examination were not necessarily an accurate indication of the actual displacement at the time of injury.

Classification—Clinical examination, surgical exploration, and examination of post-mortem specimens showed that fractures and fracture-dislocations of the spine at this level could

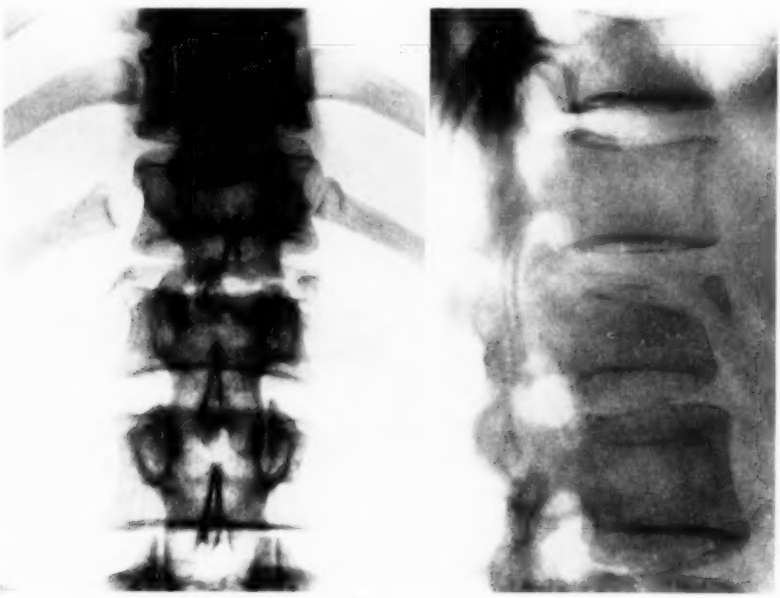

FIG. 6

Torsional fracture-dislocation between T.12 and L.1. In the antero-posterior view fracture of the right articular process of L.1 and the lateral shift of the articular and spinous processes of T.12 are shown. In the lateral view the typical "slice" fracture is shown. The torsional nature of the injury is illustrated by the dislocation of the right twelfth rib.

be divided into stable and unstable types. Instability of the spine after fracture depends upon the degree of damage to the posterior ligaments and articular processes (Figs. 3 to 5). If the posterior ligaments remained intact they acted as a fulcrum: the violence was expended upon the vertebral body and a compression fracture resulted (Fig. 3). These fractures were stable and impacted, and further violence, unless it was greater than the original force, could not displace the fragments more. The displacement was essentially one of angulation; the spinal canal was not seriously deformed and paraplegia was rare; and when paraplegia occurred the cord lesion was often incomplete and the lumbar roots escaped injury. In this series of cases there were only two examples of such fractures, and both patients had incomplete lesions of the cord with complete root escape. (It is theoretically possible in such fractures for a fragment of the vertebral body to be driven back into the spinal canal with severe damage to the cord—but we have not seen such a case. Furthermore, if the posterior ligaments

are ruptured as a result of flexion strain the vertebrae may separate behind without fracture of the body and an uncomplicated dislocation with locked articular facets is then sustained, the displacement being limited by interlocking of the articular processes—a stable injury in which paraplegia is uncommon; but again there was no such injury in this particular series of patients.)

Torsional violence with rupture of the posterior ligaments and fracture of one or both articular processes allows the upper vertebra to swing round upon the lower, taking with it the intervertebral disc and a " slice " of the lower vertebra (Fig. 5). This fracture-dislocation is unstable; the displacement can be reduced quite easily by laying the patient on his back. Consequently, radiographs taken with the patient supine, or in the lateral position with the shoulders and pelvis held in line, often show little displacement whereas if the original torsional strain is reproduced gross displacement can be demonstrated. This has been confirmed on many occasions at operation. In this type of fracture-dislocation lateral shift of the spinous processes with fracture of the articular processes can be seen in the antero-posterior radiographs and the typical " slice " fracture of the body is seen in the lateral projection (Fig. 6). A further important indication of instability is the presence of a palpable gap between the affected spinous processes from rupture of the supraspinous and interspinous ligaments. This torsional dislocation is the most common cause of paraplegia at this level, the cord being crushed between the lamina above and the vertebral body below.

Lumbar puncture—Lumbar puncture has not proved to be of assistance in diagnosis. Complete obstruction to the flow of cerebrospinal fluid has been found in both complete and incomplete cord injuries, whereas a free flow has been observed in several cases of complete lesions of the cord. Tapping the thecal space shows the presence or absence of obstruction to the flow of cerebro-spinal fluid but gives no information as to the presence or absence of spinal cord compression, or of the nature of the block—whether extra-dural or intra-dural, from blood clot or bone displacement, or simply from oedema of the cord. Lumbar puncture records no more than the anatomical state during the resting phase of an injury when neurological damage has already been sustained. It is true that demonstration of intrathecal block by lumbar puncture provides yet another indication for exploration when it is associated with progression of abnormal neurological signs, but this occurred in only one case out of sixty-eight and in this case laminectomy proved useless. In seven patients a complete spinal block disclosed within a few hours of the injury had disappeared by the end of the second month without manipulation or operation.

TREATMENT

Management of the vertebral injury—Treatment of the vertebral injury should be designed to prevent the complications of paraplegia by making nursing easy. It should restore and maintain alignment of the spine in preparation for future weight bearing, and it should free the cord and particularly the nerve roots from compression, placing them in a position of safety so that there will be no impairment of such spontaneous recovery as may occur. Thus the deformity should be reduced if it is severe, or if it encroaches upon the neural canal.

Restoration of alignment can be achieved by manipulation or by open operation. The safety of manipulative methods depends upon accurate foreknowledge of the bone damage to the whole vertebra—but despite careful radiographic examination of our sixty-eight patients we found it difficult to be certain of the extent of the bone damage. Repeated mistakes were made in the interpretation of the position of the articular processes, and this rather dangerous hit-and-miss interpretation of the exact displacement made it obvious that manipulative reduction was usually unsafe. Thus all patients in this series in whom there was severe displacement encroaching upon the neural canal were treated by open operative reduction. The operation is simple and safe, and it affords an opportunity of judging the

stability of the spine by examination of the posterior ligaments. It must be added, however, that reduction alone is not enough. If the fracture-dislocation is unstable the spine must be immobilised otherwise displacement will recur. Our experience of external fixation by prolonged immobilisation in plaster has been quite disastrous. Of sixteen patients who had been treated in plaster beds, all had severe pressure sores which took not less than two years to heal (Fig. 7). The alternative is internal fixation, and this we have found simple, safe and effective.

Technique of operative fixation.—The most satisfactory method is to fix the fractured segments by two plates bolted through one or more spinous processes above and below the level of the dislocation (Figs. 8 and 9). When the spinous processes are damaged this may not always be possible and the surgeon may have to exercise ingenuity in fixing plates to the laminae. Such fixation by plates is effective for eight to twelve weeks, by which time the spine is sufficiently stable through spontaneous fusion of the vertebral bodies.

Selection of cases for operative fixation.—The decision to operate and plate the spine depends

FIG. 7

Multiple severe pressure sores, the result of nursing in a plaster bed.

upon the displacement and the stability of the fracture, which is not always easy to assess. There is no difficulty in making such a decision in unstable fracture-dislocations with gross displacement (Figs. 10 and 11). But if there is crushing of the body with intact articular processes, and no palpable gap between the spinous processes, the fracture is stable and no matter how severe the degree of paralysis there is no indication for operative treatment (Fig. 12). But if radiographs show the typical "slice" fracture with minimal crushing of the vertebral body, accompanied by fracture of the articular processes and lateral shift of the spinous processes together with a palpable gap from tears of the supraspinous and interspinous ligaments, the spine is unstable and operative reduction with internal fixation should be performed as an emergency procedure (Figs. 13 and 14).

Nursing.—All our patients were nursed on ordinary mattresses. With the spine firmly fixed their ease of handling was quite remarkable (Fig. 15). The lumbar thoracic curve was supported by a pillow and the patient was rolled from the supine position to each side alternately at two-hourly intervals throughout the day and night. The buttocks and shoulders were supported by extra pillows when the patient was in the semi-lateral position. When he was supine the

FIG. 8

FIG. 9

Unstable fracture-dislocation (Fig. 8) reduced by open operation and fixed by plates bolted to the spinous processes (Fig. 9).

FIG. 10

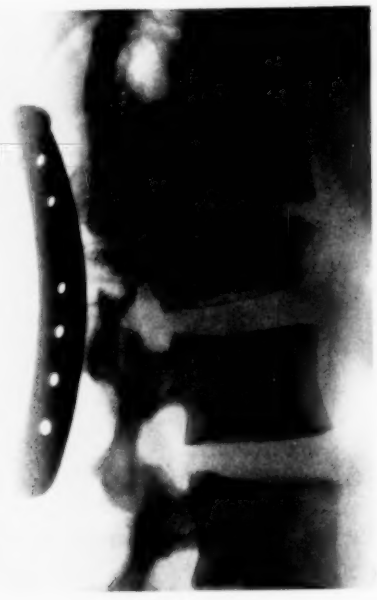

FIG. 11

Figure 10—Fracture-dislocation of T 12 on L 1 with gross displacement and clearly unstable.
Figure 11—The displacement has been reduced by open operation and the spine fixed by plates.

legs were slightly raised so that the heels did not lie on the bed; in the lateral position the knees and ankles were separated by small pads or pillows. All pressure areas could be seen and inspected at each turn and the only local treatment to the skin was washing with soap and water and occasional powdering. Early active and passive physiotherapy was applied to the upper and lower limbs as soon as the general condition permitted.

In the normal person, constant change of position is a reflex action and in this way prolonged pressure on any one area of the skin is avoided. In the paraplegic patient this mechanism is lost, so that areas of skin are subjected to pressure for just so long as the patient is left in one position. Continuous pressure for no more than a few hours causes necrosis of the subcutaneous tissue, although the full extent of such damage may not always be apparent as a superficial sore for some time. Pressure sores can always be prevented by the regime of

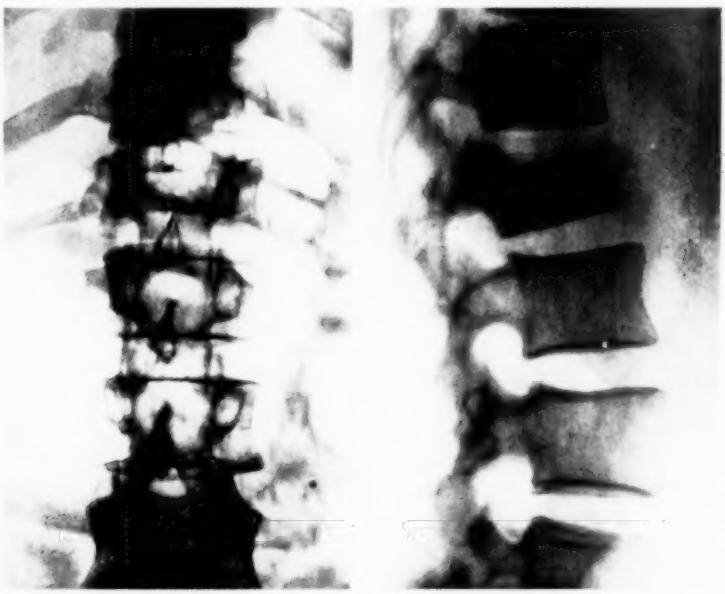

FIG. 12

Crush fracture of T.12 vertebral body. There is no lateral shift and no separation of the spinous processes. The fracture is stable

regular turning. During the past seven years we have not had one single serious pressure sore in patients so treated.

Care of the bladder and bowel The aim of early management is to protect the bladder from infection, and to prevent over-distension or persistent contraction during the long phases of inactivity and subsequent recovery. Treatment must be continued until compensatory mechanisms have been established, whether by manual compression, abdominal straining, reflex activity, or a combination of all three. Therefore the treatment employed must be the one that is most suitable for prolonged use. The emphasis should primarily be on the prevention of complications, and secondarily on the encouragement and reinforcement of reflex activity. These objects can be achieved only by effective bladder drainage and lavage. Opinions differ widely on the technique that is most appropriate. Our method of choice was by bladder drainage with an indwelling urethral catheter. By this method the bladder capacity was controlled and distension avoided. The bladder was exercised regularly and the cavity

FIG. 13
Torsional fracture-dislocation between T 12 and L 1

FIG. 14
Same case as Figure 13. The spine has been fixed by two plates.

kept clear of debris by intermittent washouts. Strict aseptic technique reduced or even removed the risk of infection of the lower urinary and genital tracts, and the state of efficiency of the bladder could be observed quite easily.

The indwelling urethral catheter we have used is of the Foley type, not larger than 18 French gauge; the catheter was changed every week; drainage was free into a bottle beneath the bed. Twice a day the bladder was irrigated with fluid and alternately filled and emptied. Care was taken to empty it completely by suction after every irrigation. Suction was discontinued when the tone of the bladder sufficed to clear its own cavity of debris during the washout. The solutions used were Suby's solution M, boric acid, or flavasole

FIG. 15

Lateral nursing position. Note the pillows separating knees and ankles. Note also the indwelling urethral catheter. Quadriplegia four weeks after injury.

according to the circumstances. Antibiotics were used occasionally but not as a routine. All patients were encouraged to drink not less than six pints of fluid each day. This method of treatment was successful in avoiding phosphatic incrustation. Rigid aseptic precautions were always taken.

Bowel function is always disturbed and too often it has been neglected. Dirty beds and soiled linen should not be accepted as inevitable sequels; the judicious use of aperients, laxatives, enemas and manual evacuation, singly or in combination, reduces inopportune bowel actions to a minimum. No patient should be allowed to remain constipated for longer than three days and the regime should be continued until a habit reflex or control by straining is achieved.

RESULTS

The results of this routine of management have been good. Patients whose spines were stabilised by internal fixation were moved freely and easily in bed with comfort and confidence. The reduction was well maintained and there were no redisplacements. Wounds healed by first intention and all patients were able to sit up quite safely in a chair by the end of the third month when bone union was well advanced.

No pressure sores occurred in our own group of cases and the absence of sores has been responsible for a great reduction in the period of in-patient treatment. The average stay in hospital in an uncomplicated case has been a little over nine months, compared with an average period of over two years for a similar group of patients with pressure sores.

No muscle or joint contractures have occurred and the return of any voluntary movement has been recognised at an early stage and encouraged.

The periods of catheter drainage varied from two to thirty-four weeks, with an average of nineteen weeks for complete lesions and seven weeks for incomplete lesions. Catheter complications developed in seven cases but did not interfere with treatment; all of them resolved quite rapidly. There were five cases of epididymo-orchitis, two cases of peri-urethral abscess, and five cases of small vesical calculi. The calculi were easily removed at the end of the period of catheter drainage.

Of the sixty-eight patients in the whole series, forty-seven were treated by us throughout, operative exploration being undertaken in thirty and internal fixation in nineteen. Of the early cases, twenty-four had complete initial paraplegia below the L.1 segment—that is, complete cord and root lesion. Of these, four later developed root recovery. Nineteen had partial root and complete cord lesion. In all these the function of the roots improved but that of the cord did not. Four had incomplete cord lesions and these remained unchanged.

Of the twenty-one late cases admitted weeks or months after the injury twelve had complete paraplegia when first examined and there was no subsequent change. Nine had root escape and in these the cord function remained unchanged but the function of the roots improved. There was not one patient in the whole series in whom the function of the cord improved.

There were three deaths from operation, one from a ruptured lung, one from a ruptured stomach lying in the thorax, and one from pulmonary embolus on the third day.

It thus appears that this method of immediate treatment has advantages in the avoidance of complications and possibly in the encouragement of recovery of function of the lumbar roots.

SUMMARY

1. Paraplegia from fracture-dislocation at the thoraco-lumbar junction is a mixed cord and root injury. The root damage can be distinguished from cord damage by neurological examination and by comparison of the neurological level with the fracture level.

2. Even though the cord injury is complete, as it usually is, the roots often escape or recover.

3. Fracture-dislocations can be divided into stable and unstable types. Because of the possibility of root recovery care must be taken to prevent further damage to the roots by manipulation of the spine or during treatment. For this reason unstable fracture-dislocations are fixed internally by plates.

4. Internal fixation also assists in the nursing of the patient. The nursing technique and the care of the bladder are described.

TUBERCULOSIS OF THE ELBOW

A Study of Thirty-one Cases

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A survey of the literature on tuberculous disease of the elbow joint reveals little reference to assessment of the disease as a whole. Most writers confine themselves to the description of individual cases or to new methods of operative treatment. Girdlestone and Somerville (1952) gave a short description of the disease and its treatment, based on the study of sixteen cases, but did not discuss the question of classification or assessment of late results. It was thought therefore that a review of a relatively larger series of cases might lead to useful information for establishing the characters of the disease. This paper is based on the study of thirty-three elbows in thirty-one patients. An attempt has been made to classify the condition and to assess the results of treatment.

General survey—Table I shows some of the statistical information obtained in the course of the review. It is well known that statistics based upon a small number of cases can be misleading, but it is felt that these figures serve a useful purpose in establishing a standard for the description of the disease. The age at onset is shown in Figure 1. The disease was commonest in the second and third decades.

CLASSIFICATION

Tuberculosis of the elbow may be divided radiologically into four main presenting types and these are given in Table II in order of severity. Three of the cases could not be classified because the original radiographs had been lost. The clinical appearance and the differential diagnosis are the same in all types. It is not intended to discuss them in detail in this paper.

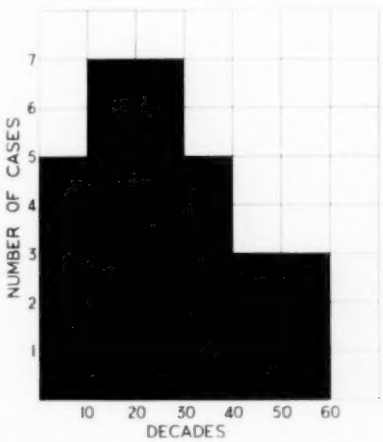

Fig. 1

Age incidence in thirty cases of tuberculosis of the elbow.

The synovial lesion—This was the least common lesion in the series though Girdlestone and Somerville considered it to be the most common. Figure 2 illustrates the degree of osteoporosis that may occur in the acute phase. Figure 3 is a radiograph of the same elbow five years later. The joint space has been preserved and clinically the patient has only terminal limitation of movement. In one case in which the diagnosis was later proved by biopsy the condition at first was mistaken for osteochondritis dissecans, because of marked overgrowth of the radial head. It is interesting to speculate whether this overgrowth is of a similar nature to that found in the head of the femur in some synovial or acetabular lesions of the hip.

The extra-articular lesion—This occurred as a presenting type in six cases. Extra-articular lesions were also seen in association with the coronoid and massive types of disease, but these are not included in this section. Table III shows the site of the lesion in each case.

It will be seen that multiple lesions are not uncommon. Figure 4 illustrates a medial epicondylar lesion in the acute phase and Figure 5 an olecranon lesion in the stage of healing. The latter radiograph shows how extensive this lesion may be without erosion into the joint.

TABLE I

CLINICAL DETAILS IN THIRTY-THREE CASES OF TUBERCULOSIS OF THE ELBOW

Number of patients		31
Number of elbows for study		33 (2 bilateral)
Age—youngest		4 years
oldest		58 years
Sex—male		21 (68%)
female		10 (32%)
Side affected—right		18 (55%)
left		15 (45%)
Diagnosis—proven		8 (24%)
not proven		25 (76%)
History of injury—present		10 (30%)
not present		23 (70%)
Time since onset—longest		32 years
shortest		6 months
average		8 years

TABLE II

CLASSIFICATION OF TUBERCULOSIS OF THE ELBOW

Type of lesion	Number of cases	Percentage
Synovial	3	9
Extra-articular	6	18
Coronoid	8	24
Massive	13	40
Unclassified	3	9
Total	33	100

TABLE III

SITE OF LESION IN EXTRA-ARTICULAR DISEASE

Medial epicondyle	2
Lateral epicondyle	1
Olecranon	1
Olecranon and lateral epicondyle	1
Medial and lateral epicondyles	1

It is obvious, however, that there is some loss of joint space and the prognosis for movement is poor. In both the olecranon lesions there was gross loss of movement. In the epicondylar lesions the outlook is more favourable and in all the cases a considerable range of movement was restored.

FIG. 2

FIG. 3

Figure 2—Radiograph in a case of synovial tuberculosis in the acute phase. Note the marked degree of osteoporosis. Figure 3—The same elbow five years later; there has been no destruction of cartilage or bone.

FIG. 4

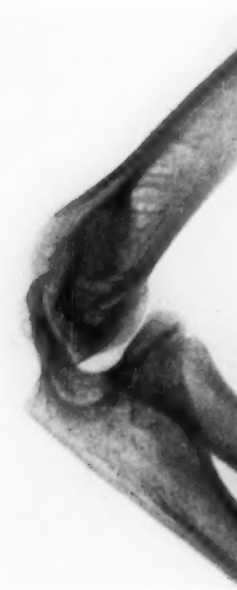

FIG. 5

Figure 4—Showing an extra-articular lesion in the medial epicondyle in the acute stage. Figure 5—An olecranon focus in the quiescent phase. The joint space is narrowed.

The coronoid lesion—Although this is strictly an extra-articular lesion it is considered under a separate heading, for it differs from other extra-articular lesions in that the joint always becomes involved eventually. The typical radiographic appearance is shown in Figure 6. The focus lies just under the articular surface of the coronoid and extends slightly into the olecranon. The lesion in the illustration extends rather more into the olecranon than is usual. Figure 7 shows the same elbow eight years later and illustrates well the extensive joint involvement.

The massive lesion (involving all joint surfaces)—This is the most common presenting type, occurring in 40 per cent of the cases of this series. Figure 8 shows an example. It is notable that a coronoid lesion is present, and it is possible that in all these cases the earliest focus is of the coronoid type. It is not uncommonly associated with posterior displacement of the

FIG. 6

FIG. 7

Figure 6—Radiograph of a coronoid lesion. The focus extends farther into the olecranon than is usual.
Figure 7—The same elbow eight years later. General invasion of the joint has occurred.

head of the radius (Fig. 9). In most cases this was only a subluxation, but in three cases the dislocation was complete. In both the coronoid and the massive lesions the prognosis for useful movement at the humero-ulnar joint is poor. The final result varied from complete bony ankylosis to a range of a few degrees of movement. In contrast a useful range of rotation was often retained.

COMPLICATIONS

These are listed in Table IV.

Sinuses—These all occurred in the types with bony foci; none of the synovial lesions were so complicated. They were most common in the extra-articular type (five out of the six cases). In all but two of the nineteen cases the sinus healed during the course of treatment.

Other tuberculous lesions—It is thought important that this should be included as a complication, in order to stress how often tuberculosis of the elbow is only one of the

FIG. 8

Radiographs of a massive lesion. Note the faint outline of a coronoid lesion in the lateral view.

FIG. 9

Posterior dislocation of the head of the radius complicating a massive lesion.

manifestations of a severe generalised tuberculous infection. Many such patients had more than one additional focus, mostly of other bones and joints.

Ulnar nerve weakness—It is difficult to say whether this is a true complication of the disease. It was noted in two cases. In one, marked wasting of the small muscles of the hand, especially the first interosseous, was observed during the acute stage; recovery gradually occurred during the course of treatment. In the other case there was permanent sensory loss associated with an adherent scar over the medial epicondyle after arthrodesis.

TABLE IV

COMPLICATIONS

Sinuses	19 (58%)
Other tuberculous lesions . .	13 (40%)
Ulnar nerve paresis . . .	2 (6%)

TREATMENT

Conservative treatment—This was by prolonged immobilisation, with treatment of the general condition in the usual way. Most patients were admitted to hospital for a period of three to six months. Streptomycin was available for only four cases; in those its effect was striking (Figs. 10 and 11).

The average period of immobilisation was eighteen months. It is probable that with appropriate chemotherapy it will be possible to shorten this, but it would be unwise to discard splintage completely, as has been done in some centres. Tuberculosis of the elbow is often in an advanced stage before treatment is begun, and complete rest of the joint is as important for healing as the use of antibiotics.

The type of splintage used was an above-elbow plaster. The plaster included the wrist for the first six months, but thereafter the wrist was left free. Study of the results has shown that this practice has been well worth while as a method of preserving some rotation of the forearm, when the rest of the elbow was virtually fused. In a few cases it was necessary to use a shoulder spica for the first three months because of a severe initial reaction. The position of immobilisation was that of the accepted best position for the elbow—a few degrees below the right angle. This position could not always be attained when the elbow had become fixed before treatment was begun.

The question of providing permanent fixation by appliances has been governed largely by each patient's occupation. In patients returning to light work the joint has been allowed free to see how it will react to use. This has been tried in fourteen cases and has not caused recrudescence of the disease. In patients returning to heavy work a block-leather support was fitted for the patient to use at his work, but the joint was left free at other times. In all these cases the patient was encouraged to discard the support after a year or two, but in most cases it was still used for work. One patient, with marked destruction of the joint, worked as a builder's labourer for five years before complaining of further discomfort.

Operative treatment—This may be considered under three headings: local excision of the lesion, excision of the joint, and arthrodesis.

Local excision of the lesion—This method of treatment was strongly recommended for the extra-articular lesion by Korner (1935). He considered it particularly important in the olecranon focus as a means of trying to prevent joint involvement, and study of the late results of this type of lesion in this series supports his view. Only one case was treated in this way, by excision of a focus in the medial epicondyle. The final result was good; an almost

complete range of movement was restored, even though the operation was followed by a persistent sinus for some months. It seems probable, however, that excision is unnecessary in the epicondylar disease, for three of the four cases studied did equally well with conservative

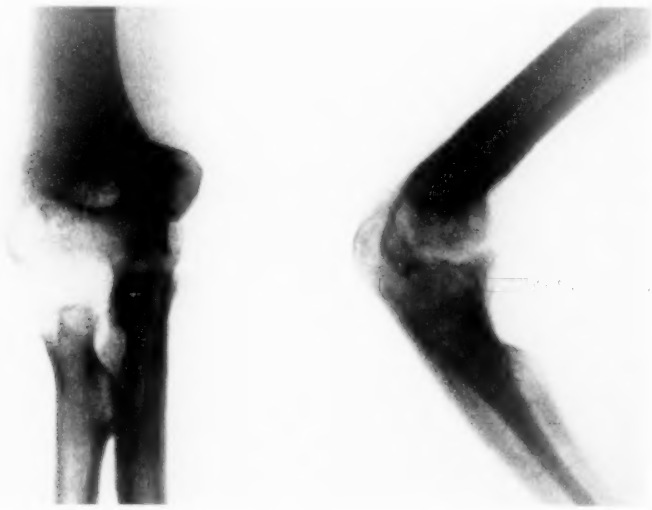

FIG. 10

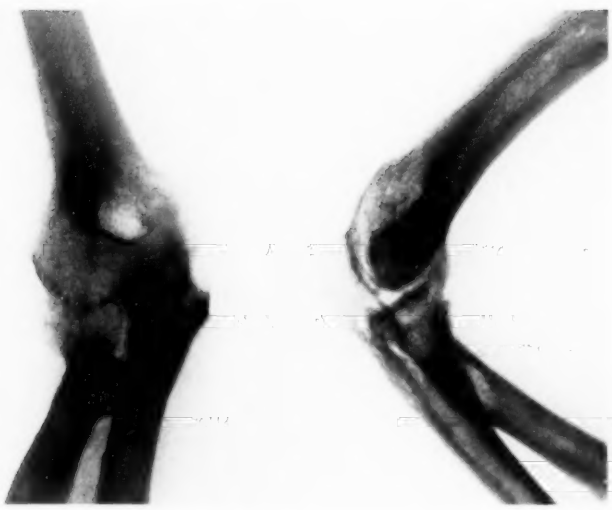

FIG. 11

Radiographs illustrating the response to treatment by streptomycin. Figure 10—Immediately before treatment was begun. Figure 11—Six months later, showing marked reossification.

treatment. It is unlikely that excision of the coronoid lesion will ever be possible without grave danger to the joint, although under streptomycin control it might be possible, perhaps by a postero-medial approach.

Excision of the joint—Excision of the joint without arthrodesis was not carried out in any of the cases in this series, and the method is only mentioned for completeness. Galli and San Martino (1951) discussed the relative merits of excision and arthrodesis. They concluded that excision cannot ensure good movement or stability, and that it should be confined to the type of case in which movement is specially important to the patient.

FIG. 12

A method of extra-articular arthrodesis using a flexible iliac graft.

Arthrodesis—This was carried out in only three cases. In each case the operation was performed for persistent pain or for recrudescence of the disease. In two cases an intra-articular fusion was carried out and in one of these there was failure of bony fusion. In the third case fusion was secured by an extra-articular method (Fig. 12). Fusion was slow and it was necessary to keep the limb immobilised for eighteen months after operation. Streptomycin was not used post-operatively and a sinus formed which took seven months to heal. Eventually the graft consolidated and intra-articular fusion now appears to be occurring. Gascó Pascual (1942) described a similar method of arthrodesis in which the fusion was solid in ten months. He obtained rather better contact for his flexible graft by dividing the olecranon and fixing the graft between the fragments.

RESULTS

The results of treatment in twenty cases observed for five years or more are given in Table V. Several patients returned to heavy labouring wearing a block-leather support. Enquiry was made into the most useful position of immobilisation. Most of the men preferred a position a little below the right angle. As already mentioned, several patients had the elbow fixed in greater extension than is usually accepted as desirable—as much as 130 degrees—and they formed an interesting group for study. Cosmetically these elbows looked better than

TABLE V

RESULTS IN TWENTY CASES OBSERVED FOR FIVE YEARS OR MORE

Died (pulmonary tuberculosis)	1
Residual symptoms (pain or persistent sinus)	5
Return to work	17
Permanent support	7
Spontaneous ankylosis	3

those fixed in the classical position. The arm hangs naturally by the side, and on superficial examination there is no obvious deformity: whereas in the usual position, the point of the elbow is prominent and the arm hangs awkwardly. From a functional point of view, also, the extended position gave advantages. Thus one patient was able to return to work in the police force, and another was working as a typist. Only two patients said that they would have preferred a position a little above a right angle. These were women who found difficulty in using the affected limb to do their hair. The disadvantages of not being able to use the

arm for feeding and for one's facial toilet are outweighed by the advantages of the extended position, and it seems that a position of about 120 degrees (30 degrees below the right angle) is the best.

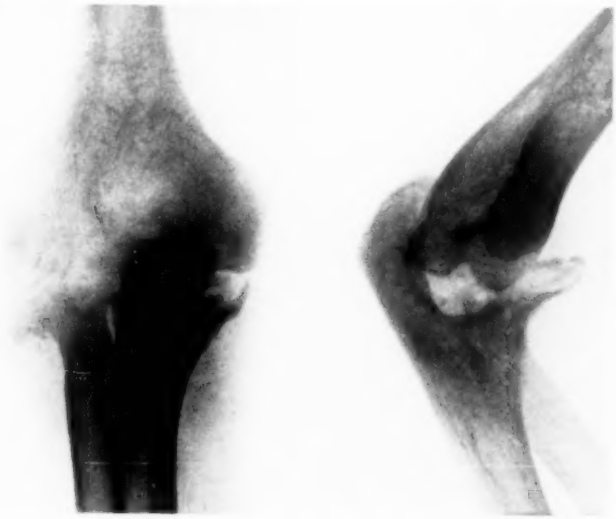

FIG. 13
A severe massive lesion in the acute stage.

FIG. 14
The same elbow six years later showing solid fusion at the humero-ulnar joint.

In three cases ankylosis occurred without operation. In all of them the elbow had been immobilised for a long time in a block-leather support and in all there had been sinuses at some time during treatment. Two of these cases are illustrated (Figs. 13 to 15). It should be

noted that the radio-humeral joint has not fused; both patients retained a range of rotation of 20 degrees about the mid-position. The third case was complicated by posterior dislocation of the head of the radius. The displaced head was excised and about 20 degrees of rotation was restored. The operation seems well worth while in cases of this nature.

It is apparent from these results that arthrodesis by operation is not essential for the healing of the lesion and should be restricted to cases in which trouble persists despite conservative measures.

FIG. 15

Spontaneous fusion of the humero-ulnar joint twenty years after the onset of disease. Note that the head of the radius has not participated in the fusion.

SUMMARY

1. Thirty-one cases of tuberculosis of the elbow have been reviewed and the general characters of the disease described.

2. The condition is classified into four types distinguishable radiologically.

3. Treatment is predominantly conservative. Operation is sometimes indicated for extra-articular lesions. Arthrodesis is advisable in selected cases but it is not essential for healing.

4. Of twenty patients observed for five years or more, seventeen returned to work, seven required permanent splintage and five had residual pain or sinuses.

5. It is suggested that the best position for fixation of the elbow is 30 degrees below the right angle.

I am indebted to the consultant staff of the Robert Jones and Agnes Hunt Orthopaedic Hospital for allowing me to follow up cases under their care, and for their encouragement and help in producing this paper.

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PREPARATION AND USE OF HETEROGENOUS BONE GRAFTS

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The successful use of frozen homogenous bone has made the bone bank an essential part of the equipment of the orthopaedic surgeon. The chief difficulty associated with such banks, however, is that of acquiring human bone in sufficient quantity and quality. Most banks have more demands than they can satisfy. Moreover, the necessity for taking bone as soon as a suitable occasion arises means that staff, time and premises have to be constantly available—a set of circumstances that does not always apply.

The use of animal bone would solve these problems, but past reports indicate that such heterogenous bone grafts have seldom been successfully incorporated in the host bone. We were, however, informed by Messrs J. Judet and R. Judet, of Paris, that they had had considerable success with heterogenous grafts prepared by a special technique. We therefore decided that the problem deserved further investigation. This paper reports our results.

OBTAINING THE BONE

We have been using bone taken from calves between the ages of six months and eight months. We selected the calf as a source because it is easy for us to get calves and to select suitable ones. Between the ages of six and eight months the epiphysial cartilages are not too large and the bone is not too dense. Bone taken from older animals was incorporated in human hosts much more slowly.

Each animal is tested with tuberculin before slaughter and a careful necropsy always follows the removal of the bone so that we are satisfied that the beast is healthy.

The calf is slaughtered separately from other animals in an empty abattoir. The carcass is slung up in hooks; the hind legs are shaved, scalded with boiling water, painted with 10 per cent formalin and amputated through the hip joints by veterinary surgeons, who use the same aseptic technique that would be observed in an operating theatre. The amputated limbs, wrapped in sterile sheets, are taken into the graft-preparation room. We have chosen hind limbs in preference to fore limbs because they are larger and because the bone is more easily prepared and is generally of a better quality. Aseptic removal of bone from the hind limbs is obviously a little more difficult, but the problem can be overcome if the technique is really scrupulous. A longitudinal incision is made from one end of the limb to the other. The incision is towelled and the metatarsus, tibia and femur are exposed and removed through it. The removed bones, held in forceps, are cut into rods of compact bone 15 to 25 centimetres long, and into grafts of cancellous bone in cubes of 15 millimetres × 15 millimetres. Strong instruments are necessary for the removal and dissection of the bones. An electric circular saw 15 centimetres in diameter, driven by a 5 h.p. motor, is used to cut up the bone. The saw and motor are sterilised at 180 degrees Centigrade. All preparation of the bone is done inside an air-conditioned room of about thirty cubic metres. Ultra-violet light is switched on twenty-four hours before and is maintained during the whole procedure. Petri dishes are exposed the whole time for bacteriological control. Communication with the exterior is by a port-hole. The operator and his staff (one assistant and a specially trained nurse) are dressed in sterile gowns and wear sterile gloves. Special spectacles are worn to protect their eyes from the ultra-violet rays.

The bone fragments are placed in a sterile bottle, which is immediately closed by a sterile stopper. The bottle is then placed inside a second tube, which is also sterile. The

* Director: Professor M. Guilleminet

whole is then numbered and labelled. Since the bottles are transparent the nature of each graft can be seen, so that the statement on the label can be checked. Small fragments of the grafts are cultured for both aerobic and anaerobic organisms and the double bottles are placed in the refrigerator and stored at —35 degrees Centigrade until they are ready for use.

No bone is used earlier than one week after freezing. This allows time for the bacteriological report and for us to be certain that the graft is sterile. Sterility of the graft has been difficult to obtain. At first many grafts had to be rejected but the various sources of contamination were traced and eliminated and sterility is now the rule. We do not consider that any of our precautions are excessive. Many of the failures in the grafting of compact bone appeared to be due to contamination during the preparation of the grafts.

When the grafts are to be used the outside bottle is opened and the inside bottle is dropped on to the surgeon's table so that its opening can be delayed until the last moment.

PREVIOUS WORK ON HETEROGENOUS GRAFTING

Heterogenous bone grafting has a long history. In 1885 Ollier published the results of sixty heterogenous grafts, most of which were failures. He concluded, nevertheless, after successfully transplanting rabbit bone into cat, that one of the chief factors determining success was the size of the fragments, which must be small. He used refrigeration to store homogenous and heterogenous grafts and claimed one success in grafting a fragment from a rabbit which had been dead for twenty-four hours and kept at a temperature of 2 degrees Centigrade. Since Ollier's report, Schmitt (1893), Barth (1895), Axhausen (1909), Baschkirzew and Petrow (1912), Calvé (1935) and Orell (1937) have published experimental work on heterogenous grafting, but have not obtained uniformly satisfactory results. Indeed it was not until 1949, when the Judet brothers used calf bone refrigerated at low temperatures, that incorporation of such grafts in human bone was shown to occur with any regularity.

PRELIMINARY EXPERIMENTS

Our own experiments began in 1949. At first we used transplants of comparatively small size—10 millimetres × 4 millimetres × 4 millimetres. We tried many varieties of graft: refrigerated, non-refrigerated and freeze-dried, compact and spongy, onlay and inlay. In onlay grafting we have placed the graft subperiosteally without erasing the host cortex. In inlay grafting we have cut trenches 5 millimetres × 25 millimetres with an oscillating saw, and we have been able to place calf bone and autogenous bone in the same trenches, thus providing a control.

We have now performed thirty transplants of calf bone into nineteen dogs and eleven guinea pigs. We used the radius as the host bone in the dog. In the guinea pig we used the femur, nibbling the lower metaphysis with a rongeur, holding the graft in place on the sawed bone by suturing muscle over it.

Material studied—We made complete histological studies of fifteen calf-dog transplants (Figs. 1 to 5).

Non-refrigerated calf-dog transplants—Six transplants were studied. Two were inlay transplants of cancellous bone; they were examined on the fortieth and fiftieth days. Four were onlay transplants of compact bone; they were examined on the twenty-first, forty-second and seventy-seventh days.

Frozen calf-dog transplants—Nine transplants were studied. Three were cancellous transplants, of which two (inlay transplants) were examined on the sixty-second and sixty-fourth days and one (onlay) was examined on the sixtieth day. Six were compact transplants, of which five (inlay) were examined on the eighteenth, thirty-sixth, forty-second, sixty-eighth, and sixty-eighth days, and one (onlay) was examined on the sixty-second day.

Observations—Our observations from these experiments were as follows. 1) Cancellous bone was not as satisfactory as compact bone for experimental study because its wide texture made examination difficult. 2) Onlay transplants placed under the periosteum without

FIG. 1

FIG. 2

An implant of refrigerated calf bone in the shaft of the radius of a dog. The implant was fixed into the host bone by intramedullary impaction. Figure 1—Transverse section of a specimen obtained eighteen days after operation. Note the endosteal reaction. Figure 2—Higher magnification. The graft and the host bone are united by bone trabeculae and by osteoid tissue. (Preparation by Dr Feroldi.)

FIG. 3

FIG. 4

Graft of refrigerated calf bone into dog radial shaft. Figure 3—Transverse section on sixty-eighth day. Excellent incorporation of the graft. The enlargement of the Haversian canals is evidence that remodelling of the bone is still taking place. Figure 4—Same preparation in higher magnification.

opening up the host cortex and with no other fixation than muscle-suture did not " take " as regularly and as certainly as did the control homo-transplants. It should be emphasised that the onlay technique was not merely subperiosteal implantation of the graft, for the graft bed was very vascular and had been stripped of some surface bone in the process of periosteal elevation. 3) In all cases of inlay grafting of refrigerated calf bone incorporation of the graft was complete microscopically and macroscopically. 4) In most of the cases when grafts were of non-refrigerated calf bone the " take " was uncertain.

Histologically, successful grafts showed a progressive remodelling in the transplanted bone exactly comparable to that in autogenous grafts. Generally speaking we have obtained results similar to those of Reynolds and Oliver (1950).

LATER EXPERIMENTS

The second series of experiments was begun in 1950. It included a study of heterogenous transplants of larger pieces of compact bone. In most cases the experiments consisted of

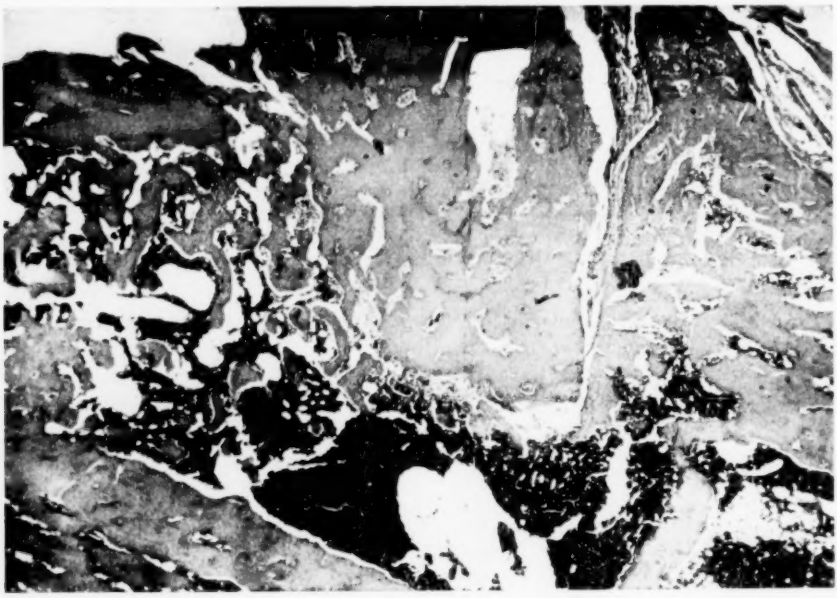

FIG. 5

Transplant of non-refrigerated compact calf bone into the femoral shaft. Specimen obtained four days after operation. Longitudinal section. The graft is united to the host bone by several fine lamellae, the bone reaction resembling throughout an early creeping substitution. Elsewhere the graft is separated from the host bone and fibrous tissue has been deposited between them.

resection of the shaft of the radius in dogs and bridging the defect by a heterogenous graft (Figs. 6 to 8). The graft was cut to a half-lap joint at each end and fixed by two screws. The limb was then fixed in plaster-of-paris, but because of rapid soiling and destruction of the cast by the animal external fixation seldom exceeded three to eight days.

We have also performed epiphysial resection with replacement of the articular ends of the bones. This experiment was carried out on the humerus of the dog. The grafts were taken from sheep of the same size as the dog. They were preserved by freezing. Fixation was by a half-lap joint by the technique of Merle d'Aubigné.

Material studied. *Shaft resections*—Eight transplants were observed. Three were grafts of

non-refrigerated calf bone bridging gaps. Of these dogs one died from pneumonia five days after operation; the other two are still alive. Five transplants were of refrigerated calf bone bridging gaps. Of these five dogs one died in a kennel epidemic six months after operation. In one the graft was extruded without suppuration six months after operation; its fixation had been inadequate. Two dogs are still alive with the graft in situ. The fifth dog was killed twelve months after operation.

Epiphysial articular resections—Two transplants were observed. One was a graft of sheep bone replacing the uppermost quarter of the humerus. The dog is still alive and the graft is well incorporated. The other was a graft of refrigerated sheep bone replacing the lowest quarter of the humerus.

Observations and conclusions—Our conclusions from the second series of experiments are as follows. 1) It is necessary that the grafts should be fixed firmly. Extrusion of the transplant has occurred when screw fixation was inadequate. 2) After grafting, the limb must be immobilised. The difficulty of immobilisation in animals has caused some pseudarthroses

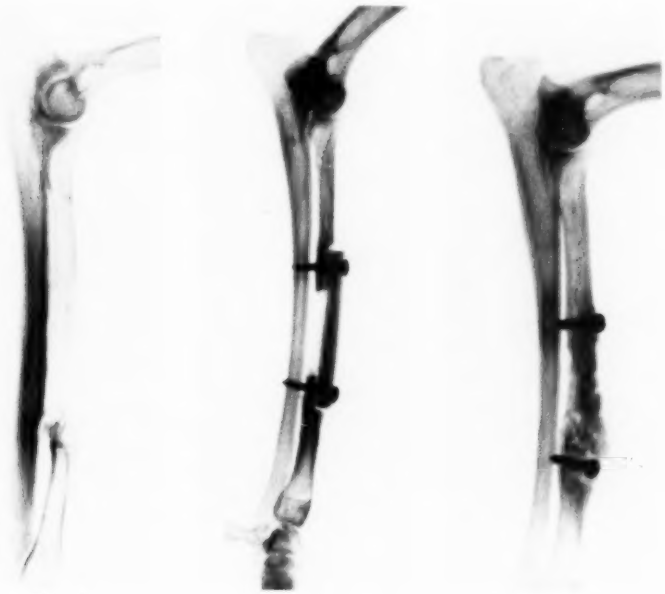

FIG. 6 FIG. 7 FIG. 8

Figure 6—Control animal. Ten months after resection of the shaft of the radius. Loss of substance persists. Figure 7—Resection of shaft of the radius. Replacement with refrigerated calf compact bone. Radiograph thirty-eight days later. Figure 8—Same animal. Radiograph after 163 days.

to develop in the middle of the grafts during the remoulding process. 3) Heterogenous grafts of non-refrigerated compact bone are unsatisfactory for the bridging of large defects. The grafts gradually disappear or simply sequestrate. The part of the graft immediately adjacent to the host bone can be partly incorporated. 4) Pseudarthrosis in the centre of the graft or at its end has a tendency to spontaneous union after about one year. 5) Heterogenous transplants are not satisfactory for replacement after epiphysial resection. The joint in the neighbourhood of the graft becomes stiff and crushing of the epiphysis occurs, producing changes similar to those seen in osteochondritis.

We considered that these results justified a trial of refrigerated calf bone in human surgery.

THE USE OF REFRIGERATED CALF BONE IN HUMAN SURGERY

We have used refrigerated calf bone in eighty patients. The operations in which grafts were used included arthrodesis of the hip, spinal fusion for Pott's disease, spondylolisthesis and sciatica, and filling of bone cavities (Figs. 9 and 10).

In general the results are comparable with those obtained from autogenous grafts. In eight cases unsatisfactory results were obtained. In six of these failure was due to infection: three infections occurred when the operating theatre was under repair and the operating conditions under suspicion. In one case calf bone was used to replace a human lunate bone; the graft was not incorporated and was partly extruded. In one other failure contact with the host bed was unsatisfactory. Altogether in eight out of eighty patients failure was associated with sepsis, a similar incidence to that occurring in autogenous grafting operations.

FIG. 9

FIG. 10

Figure 9—Idiopathic scoliosis. Fusion with refrigerated calf bone. Figure 10—Same patient ninety-six days after operation. Note the considerable quantity of new bone which has been deposited.

We have noticed that when large amounts of refrigerated bone are used, as in operations for spinal fusion in idiopathic scoliosis, a collection of serous fluid may form around the graft. This may discharge during the next few days or it may be aspirated. The presence of this fluid does not appear to prevent the incorporation of the graft.

In some of our earlier operations we used long lengths of bone obtained from older animals. This more massive bone took much longer to incorporate. Exploration of such a graft six months and one year after the original operation showed non-union.

DISCUSSION

We believe that many of the failures in heterogenous and in autogenous grafting may be explained by mistakes in the preparation of the grafts or of their beds. A particularly rigorous aseptic technique is necessary, for the procedures necessary in the preparation of the grafts allow many opportunities for contamination. The preparation of the bed is of

great importance. It must be healthy and vascular, it must allow firm fixation of the graft, and the fragments to which the graft is to be fixed are not to be regarded as if they were inert prostheses. They must not be cut with a circular saw because this will produce heat necrosis of the surface of the bone.

When all these conditions are fulfilled the incorporation of grafts of heterogenous bone is satisfactory and in all ways comparable with the results obtained from autogenous grafts. We have demonstrated this in operating on idiopathic scoliosis by grafting the upper part of the spine with heterogenous bone and the lower part with autogenous bone. Biospy later showed no difference between the two in either the naked-eye appearance or histology, although it must be admitted that in some cases, especially those in which grafts had been taken from older animals, incorporation does appear to be a little slower if heterogenous bone is used.

SUMMARY

1. The preparation of heterogenous grafts of calf bone is described.
2. The results of experimental application of such grafts in dogs and guinea pigs are recorded.
3. The results of eighty heterogenous grafts in humans are reported.
4. It is concluded that if the conditions are carefully controlled the results of heterogenous grafting are satisfactory.

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DEVELOPMENT OF CONGENITAL DISLOCATION OF THE HIP

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The development of congenital dislocation of the hip is one of those fascinating puzzles in orthopaedics in which the pieces are relatively complete but the picture which results presents some flaw, suggesting that minor adjustments here and there might give a better result. In this paper no attempt is made to review the many well known theories already widely recorded in the literature, but rather to try, by minor adjustments of the pieces we already have, to produce a somewhat modified picture. With this in view we must first know what pieces are at our disposal and in doing this the findings of others are considered in conjunction with the findings in thirty-five consecutive open reductions which have been undertaken at the Wingfield-Morris Orthopaedic Hospital during the past four years.

Types of dislocation—In the thirty-five hips which have been explored, two distinct types of dislocation were found, which would fit in with the "teratalogical" and "typical" classification described by Hass (1951).

In three hips (two patients) at open reduction the capsule was adherent to the femoral head, which was pitted and irregular. The acetabulum was filled with dense fibro-fatty tissue which was adherent to the articular cartilage. It was difficult to reduce these dislocations. One of these patients had bilateral club feet and club hands but the other had no other congenital abnormalities. The appearance was quite different from that found in the remaining thirty-two hips which would come into the class of "typical dislocations." Thirty-one of these were complete dislocations and one was a subluxation. In these there were no capsular adhesions, the femoral head was well shaped and smooth and, if the pad of fat was enlarged, it certainly was not adherent to the articular surface of the acetabulum.

It is the etiology of the "typical dislocation," comprising 90 per cent or more of the total, that is under consideration in this paper.

The time of dislocation—It is extremely difficult to be certain when dislocation occurs. It is probably a gradual process spread over a considerable time, the stage of subluxation being passed through before dislocation is finally established. But whether it develops before or after birth is uncertain. There seem to be only two certain facts: that since the head of the femur and the acetabulum are formed together the head is at first in the acetabulum; and that if complete dislocation is going to occur it will be present before the age of two years. Between these points much of what happens is a mystery, but it can be said that although minor degrees of subluxation can be found at birth, very few complete dislocations other than of the "teratological" group have been seen so early. On the other hand, in slightly older children dislocation is commoner than subluxation and this suggests that dislocation occurs sometime after birth but that the predisposing factors are present at the time of birth. The conclusion may be drawn that subluxation is converted into dislocation by some alteration that takes place in the position of the limbs. It has been suggested that weight bearing is an important factor in completing the dislocation, but since many complete dislocations are diagnosed before weight bearing has begun, it seems more likely that the only effect weight bearing has on the early course of the disease is to facilitate its diagnosis.

Direction of the dislocation—The literature shows that there is great variation of opinion about the direction in which the dislocation occurs. Classically it is said to be a posterior dislocation and certainly in a large number of older children the head does lie posteriorly, but even in some older patients it is palpable in an antero-superior position. In the thirty-one

dislocations in this series, with the hip extended the femoral head lay against the ilium antero-superiorly to the acetabulum in all but two. In these, both of which were seen after the age of four years, it lay above the joint. Although the number is far too small to allow conclusions to be drawn, these facts do lend support to the observations of others that the primary dislocation is antero-superior, but that with time and weight bearing the femoral head often passes posteriorly—influenced no doubt by the deflexion of the pelvis, the attachment of the glutei and the degree of anteversion of the femoral neck.

Ossification centres—Often in a young infant the first evidence of subluxation of the hip is to be seen in retarded development of the ossific nucleus of the femoral head as compared with the other side. At the same time it may be noticed that the bony roof of the acetabulum is defective, being more oblique than usual, but an arthrogram at this time shows that the cartilaginous acetabulum is normal and that the apparent obliquity of the roof is really due to retarded development in the ossific nucleus of the ilium rather than to a true congenital dysplasia. The arthrogram will also show the head to have a perfectly normal outline. All that is apparent is that there is a delay in ossification with some displacement of the femoral head in what otherwise seems to be a normal joint.

Changes in the acetabulum—Apart from the defective ossification already mentioned, other changes take place in the acetabulum as the deformity progresses. If the stage of subluxation persists, the lip or limbus antero-superiorly is progressively flattened outwards so that the cartilaginous roof as well as the bony one becomes oblique and inefficient. But when dislocation occurs and the femoral head crosses the lip the limbus posteriorly turns into the joint. In all the thirty-one "typical dislocations" which were explored, the limbus was inverted. In one other, which was only a subluxation, the limbus was not turned in. The Haversian pad of fat is also enlarged, but in this series it has not been found to be large enough to interfere with reduction. The ligamentum teres is sometimes absent, and often hypertrophied, this latter change suggesting that the process of dislocation has been gradual rather than sudden. It has also been suggested by Badgley (1949) and others that the acetabulum faces more to the front in congenital dislocation.

The power of suction in preventing dislocation of the hip has often been recorded. Whatever its practical value may be, it is interesting to note that in the foetus, if the muscles and ligaments are divided, the suction in the hip will resist a force of three-quarters of a pound weight or even more, but anything which interferes with the smooth roundness of the acetabulum will break the suction.

Changes in the upper end of the femur—Apart from the obvious delay in ossification already mentioned, the most important change in the upper end of the femur is anteversion. There is probably no one point about congenital dislocation of the hip that has caused more controversy than the significance of anteversion.

Le Damany (1908) suggested that the whole sequence of events ending in dislocation was the result of anteversion, and enlarged on this hypothesis by explaining how anteversion developed. In more recent years, Badgley (1943, 1949) has produced further evidence in support of the belief that anteversion is a very important factor. Unfortunately, treatment based on the correction of anteversion by osteotomy has never proved entirely satisfactory.

Combined with anteversion, the neck-shaft angle may be altered to produce varying degrees of coxa vara or valga, two deformities easily confused radiologically in the presence of anteversion. Also the size of the femoral head may vary. In early specimens its size is probably unaffected, although the ossification centre may be small, but in hips with old unreduced dislocations it is small and misshapen.

Late changes—The anatomy of the old, unreduced dislocation has been fully described by Fairbank (1930), and no repetition is necessary here, but there are certain points of particular interest. The acetabulum has changed from its usual circular shape to become triangular. The apex of the triangle is upwards with the base below; facets are sometimes found on the

posterior wall of the acetabulum, on the femur in the region of the intertrochanteric ridge and occasionally on the lesser trochanter.

THE SIGNIFICANCE OF THE FACTS

Given these facts, the problem is to determine which are primary and which are secondary and what is their relative significance in the ultimate deformity, for only with this knowledge can a logical line of treatment be evolved.

The limbus—In this series there is one factor which has proved so consistent that it must merit careful consideration. The limbus was found to be inverted into the joint in all the hips explored for complete dislocation, and not inverted in the one hip explored in which there was only a subluxation. That the limbus is inverted in dislocations can also be regularly demonstrated by arthrography. This finding is in fact so constant that the inversion of the limbus must surely be of some significance in the development of the deformity, and if we could determine the mechanism of inversion we might gain some further information as to the etiology.

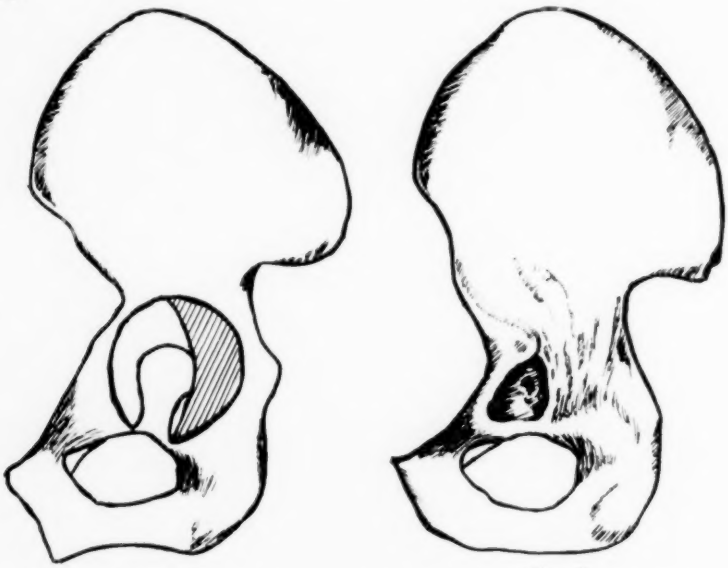

FIG. 1 FIG. 2

Figure 1—Diagram of an acetabulum with the infolded limbus. Figure 2—Drawing of the pelvis from a case of old dislocation showing the triangular acetabulum placed anteriorly with a broad thin bridge of bone covering the posterior part. Compare with Figure 1.

The limbus (labrum glenoidale) is a fibrocartilaginous rim attached to the margin of the acetabulum, which it deepens (Gray's Anatomy 1949). When examined in the fresh specimen taken at birth it is largest posteriorly and postero-superiorly, where it forms a definite sharp-edged lip which is soft and elastic. In the congenitally dislocated hip, the limbus is found turned into the joint to a varying extent, forming a white, glistening crescent like the meniscus in the knee. It lies in the postero-superior position in the acetabulum and is sometimes only a thin outer rim. But whether large or small it is always posterior, extending forwards and involving the upper lip to a variable extent.

To study the course of this inverted limbus in the untreated hip it is easiest to start with the end-result. Fairbank (1930), describing the triangular acetabulum of old untreated hips, wrote: "The edges in some cases are lipped, especially the posterior which may overhang

FIG. 3

Congenital dislocation of the hip treated conservatively. Small centres of ossification can be seen above the femoral head.

FIG. 4

FIG. 5

Figure 4—Same hip. The ossific centres have coalesced producing an appearance similar to an infolded limbus as seen in an arthrogram but composed of bone. Figure 5—Same hip. Arthrogram showing the unossified limbus folded over into the joint superiorly.

the cavity to a marked degree." He later went on to show that this posterior lip is large enough to have a facet on it, and illustrated that it is within the joint capsule. When these observations are taken into consideration and the acetabulum of an early congenital dislocation of the hip with the limbus turned in is compared with the later triangular one (Figs. 1 and 2), the impression is irresistible that the straight overhanging posterior lip, large enough to contain a facet and all intracapsular, is in fact the inverted limbus which has not—as is commonly supposed—atrophied, but has undergone ossification.

In the light of this hypothesis examination of earlier radiographs takes on a new significance. Perhaps the multiple nuclei sometimes seen between the femoral head and the bony roof of the acetabulum are signs of ossification not in the cartilaginous roof but rather in the compressed inverted limbus, being broken and irregular because of the distortion

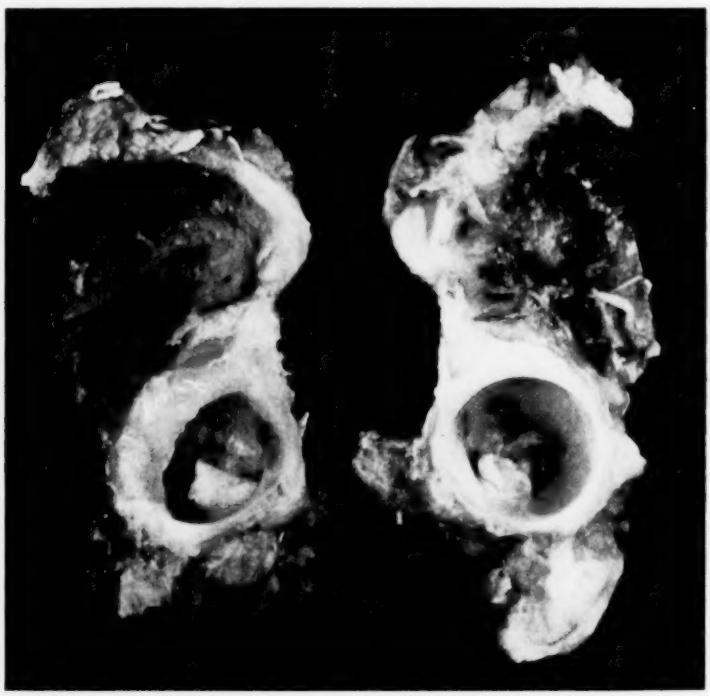

FIG. 6

Two acetabula from the same newborn child. The one on the right is normal. The one on the left shows the limbus turned in artificially as described in the text.

which is present. Figures 3 and 4 show a sequence of events that is not uncommonly seen in the course of conservative treatment: the multiple small nuclei fuse to form a reasonably realistic appearance of an inverted limbus in bone compared with the cartilaginous limbus as seen in an arthrogram (Fig. 5).

So constantly is the limbus found inverted into the joint that it is important to explain the phenomenon. As already mentioned, the limbus in the fresh specimen is a very definite structure which is largest posteriorly and superiorly. It is soft and elastic. It can easily be inverted into the joint by pressure and just as easily it springs out again. After removal of the femoral head it shows no tendency whatever to invert under the force of its own elasticity, so that some pressure must be applied to it from without. It has been suggested that the femoral head dislocates posteriorly and comes to lie on the posterior lip, forcing the limbus

towards the centre of the joint. There are two objections to this supposition. Firstly the limbus is inverted in those hips in which the head lies antero-superiorly; and secondly, any attempt in the fresh specimen to invert the limbus with the femoral head will at once show how unsuitable the femoral head is for this purpose.

Fairbank described the presence of a facet on the posterior lip of the acetabulum which, as already shown, may be the inverted limbus, and also the presence of facets on the femur in the region of the intertrochanteric crest or lesser trochanter. These facets are possibly the result of contact between these two regions. If this is in fact the case, it may be the contact of this part of the upper end of the femur on the limbus that results in its inversion.

In an attempt to reproduce this inversion experimentally in a fresh specimen, the muscles were dissected from the pelvis and femur. The capsule was divided circularly and the ligamentum teres was cut. The head of the femur was dislocated antero-superiorly by forced lateral rotation and the femur fastened to the pelvis in this position with string. The specimen was immersed in strong formol saline for two days, after which the string was cut and the bones were separated. The limbus was found to be turned into the joint in a realistic manner, as shown in Figure 6. In this particular instance it was the intertrochanteric ridge close to the lesser trochanter that was in contact with the limbus.

While this experiment is open to the criticism that it is entirely artificial, it does at least show that in the position of dislocation a part of the femur comes into close proximity with the posterior limbus and that this part of the femur is a suitable shape for causing the inversion, and thereby lends some support to the theory of Le Damany that the dislocation was due to anteversion. Unfortunately for this theory, anteversion is such a variable factor.

Anteversion – Much investigation has been carried out to determine the normal anteversion angle. While the results have been variable, a rough estimate shows that anteversion at birth is about 25 degrees and that it decreases during growth to 5 or 10 degrees when growth is complete (Kingsley and Olmsted 1948). Personal observation in a small number of foetal hips has largely confirmed the findings of others. Considerable racial variation has been reported with variations from 0 degrees to 45 degrees but the races in which the anteversion angle is the greatest are not necessarily those in which there is a high incidence of congenital dislocation of the hip; nor is the converse true (Martin quoted by Hass 1951).

In the congenitally dislocated hip even greater variations are reported, ranging from the normal up to 90 degrees. The more extreme degrees tend to be found in older patients. These findings are of necessity mainly taken from post-mortem specimens because of the difficulty of estimating the angle with any degree of accuracy during life, especially in young infants when the ossific nucleus may not be visible, so that our knowledge of the progress of anteversion in congenital dislocation of the hip is rather slender and it is still far from certain how much is primary and how much secondary. Furthermore, many of those with great experience of the condition have doubted its importance even if it does occur. Fairbank stated that only on rare occasions had he found anteversion to be of significance, a view supported by Gill (1948), who maintained that although anteversion is present in all congenital dislocations to a certain extent, it is seldom necessary to correct it by operation. On the other hand Krida (1928), Badgley (1949) and many others have stressed its importance, and there are certain other factors which make the theory of Le Damany attractive. Briefly, this theory postulates that if the femoral head and neck point forwards, as with excessive anteversion, so long as the hip is flexed there is no tendency for dislocation to occur, but with extension the femoral head will be levered against the anterior capsule, the fulcrum being the posterior lip of the acetabulum. The capsule stretches, allowing at first subluxation and later dislocation, when the head crosses the lip. All would be well with this theory if extreme anteversion were present in all congenitally dislocated hips. But this is not the case. While strictly speaking, anteversion is a relationship between the femoral neck and the femoral shaft – a relationship that is relatively stable even if it does alter to a certain extent during the growth period –

the " position " which is likely to produce subluxation and dislocation in the way described above is lateral rotation, and we must appreciate that in the hip joint itself anteversion and lateral rotation are one and the same thing, and that the effect of lateral rotation will be increased by any anteversion which may be present according to the formula: 90 degrees lateral rotation = 45 degrees lateral rotation + 45 degrees of anteversion = 90 degrees of anteversion. Or, to put it another way, anteversion is lateral rotation of the upper end of the femur without lateral rotation of the lower end. This interpretation has a number of facts to support it.

Firstly, there is the mechanism, already discussed, by which the limbus is inverted into the joint.

Secondly, there is the ease with which an early subluxation can be reduced by medial rotation without the assistance of abduction or flexion. The view is widely held and supported

FIG. 7

FIG. 8

Figure 7.—The "other" hip which was at first thought to be normal is now subluxated. Figure 8.—The same hip two months later after a seventy degrees rotation osteotomy.

by Hart (1942, 1949) that subluxation is really a stage in the development of dislocation. If this observation is correct, it would be only logical to say that any modification to the region of the hip joint that would convert a subluxation into a normal joint should have prevented a potential dislocation. But such a modification would have to be undertaken before secondary adaptive changes had developed to confuse the result. Many authors have pointed out the frequency with which, in apparently unilateral dislocation, the other hip is in fact defective and in due course will subluxate or even dislocate. Hart attributed this to a primary dysplasia of the acetabulum. Such a hip is shown in Figure 7, which illustrates a case in which the left hip had been successfully treated for a complete dislocation but the right hip is now subluxated. This subluxation can be reduced by putting the hip into medial rotation and the reduction can be maintained if a suitable rotation osteotomy is done (Fig. 8).

Thirdly, after removal of the obstruction at open reduction, the hip is perfectly stable in a position of full medial rotation, which eliminates the evil effects of lateral rotation or

anteversion, or in the frog position which also tends to neutralise anteversion. From this it may be inferred that anything that prevents lateral rotation will make the joint stable.

Fourthly, the foetal alignment of the hips involves a high degree of lateral rotation with flexion.

Lastly should be mentioned the effect of lateral rotation as seen experimentally in the hip of a foetus or newborn infant at post-mortem. In one such experiment the hips of a thirty-one week foetus were used. The muscles, capsule and ligaments were removed but the acetabulum and femoral head were left intact. The power of suction was such that a force of three-quarters of a pound was required on a spring balance to break it. The suction was also an excellent guide as to when subluxation occurred; probably the most accurate guide that could be obtained. In these particular hips the angle of anteversion was between 45 degrees and 50 degrees. With the hip fully flexed (160 degrees), 70 degrees of lateral rotation of the femoral shaft was possible without breaking the suction. With the hip extended it was impossible to rotate the femur nearer to the neutral than 20 degrees of medial rotation. With the hip flexed 90 degrees, neutral rotation could just be reached, but if the hip was abducted some lateral rotation was possible.

There is reason to suppose that anteversion will, given time, increase or decrease. To understand how readily this can happen under the influence of outside force, we must appreciate how and to what extent the femur grows in length at its upper end. This growth seems to be made unnecessarily difficult because of the presence of the femoral neck. In the foetus the upper end of the femur has a single epiphysis just like the lower end. One " condyle " is the femoral head and articulates with the acetabulum, the other " condyle " is the greater trochanter and has, of course, no articulation. Later the two " condyles " are separated by the neck and form two separate epiphyses. Continued growth with such an arrangement entails extensive remodelling throughout the growth period, and such remodelling naturally lends itself to changes in shape. The extent of growth at the upper end of the femur is clearly shown by the growth lines in Figure 10, though apparently more growth takes place in the neck than from the trochanteric metaphysis. The amount of growth shown has taken place in about seven months.

Other changes. Other changes in the pelvis, acetabulum or upper end of the femur can be accounted for as due to simple aplasia, the result of ineffective use or to abnormal pressure of one part on another. In several open reductions it has been found that the infolded limbus has been pressed into the articular cartilage of the acetabulum resulting in a marked indentation even at an early age. At some time these changes become irreversible but there seems to be no reason to suppose that they are other than secondary or that there is any primary aplasia or dysplasia of the acetabulum itself.

DISCUSSION

From these facts we can draw a fairly clear-cut picture of how congenital dislocation develops from what is at first a normal joint. For example, we can visualise the hip of a foetus of about thirty to thirty-five weeks. The acetabulum is cartilaginous and normal. The upper end of the femur is also cartilaginous with 45 degrees to 50 degrees of anteversion, which is normal. There is no suggestion of dislocation or subluxation and the hip is flexed. So long as it remains flexed it is "safe." But whenever the hip is extended, either it must go into medial rotation or abduction or both, or a considerable strain will fall on the neck of the femur and the anterior capsule of the joint, tending to twist the femoral neck and stretch the capsule. This being the case, one of three things will happen: 1) Nothing will give way under the strain and the excessive anteversion will remain without subluxation or dislocation. Clinically we occasionally meet this unsightly condition, the patient having excessive medial rotation and virtually no lateral rotation. 2) The upper end of the femur will gradually yield under the intermittent pressure so that the excessive anteversion will be slowly moulded away and a

normal hip result. 3) The anterior capsule will stretch, allowing subluxation and later dislocation to develop. As the capsule gives way, less force will fall on the femur so that there will be less tendency for the anteversion to be corrected and an excessive degree will persist after birth and, should the anterior position of the head persist, the angle will be increased. Subsequently, all the changes previously described will develop.

This hypothesis is based on the finding of the extraordinary constancy with which the limbus or labrum glenoidale is inverted into the joint in so-called typical congenital dislocation of the hip and evidence is presented suggesting that this inversion is the result of an antero-superior dislocation, the result of extension of the hip in the presence of lateral rotation, aided and abetted by anteversion. If the force producing the inversion persists long enough, the limbus will not again evert. It is natural for the limbus to get harder and finally to undergo

FIG. 9 FIG. 10

Figure 9.—Congenital dislocation of the left hip in a child of twenty months. Figure 10.—Same hip fifteen months later. There is a full range of movement and normal stability. Harris's growth lines are clearly visible.

ossification—a sequence of events that may contribute to the increasingly poor results of conservative treatment with advancing age.

The proof of a hypothesis must always be in its application. If the sequence of events described is right, it should be possible, up to the time when secondary changes are irreversible, to obtain a good result in just so long as is required to turn the limbus out of the joint and permanently to prevent the laterally rotated position at the hip. That this can happen in a certain number of hips by conservative means alone if given time is undoubtedly true, but if it were possible to evert the limbus with certainty and rapidity, or even to excise it as previously reported (Somerville 1953), it should be possible to effect a good result in a short time. While early removal of the inverted limbus has the advantage of producing a relatively normal acetabulum as quickly as possible, it has the disadvantage of not allowing sufficient time to elapse for the anteversion to correct itself naturally if it is going to, and a rotation osteotomy must be done to reduce the time of immobilisation to the minimum.

It is not in the province of this paper to report the results of treatment, but one example is given which is encouraging (Figs. 9 and 10). It is that of a child aged twenty months at admission. The hip was pulled down on a frame and abducted for four weeks; the limbus was then excised. Five weeks later a rotation osteotomy of 60 degrees was done, and after six weeks in plaster movement was begun without restraint, the child walking when she wanted to, four and a half months after admission. A year and three months after operation the clinical result is excellent with full movement and normal stability. Radiologically the acetabulum has developed well. Generally speaking, the great majority of hips so treated have progressed similarly so far.

CONCLUSIONS

Based on the constancy with which the limbus is inverted into the joint in a typical congenital dislocation of the hip, a hypothesis is presented which suggests that the sequence of events leading to established dislocation is: 1) lateral rotation aided and abetted by anteversion; 2) extension of the hips causing subluxation; 3) dislocation and inversion of the limbus; 4) secondary changes in the upper end of the femur, pelvis and acetabulum which will also develop if the deformity does not progress beyond a subluxation.

A pen picture is drawn showing how anteversion is either moulded away during growth to produce a normal hip, or persists with or without dislocation. The fate of the persistently inverted limbus is discussed and a line of treatment based on these findings is briefly considered.

I would like to acknowledge the help and advice of Professor Trueta in this investigation, and also the co-operation of Mr J. C. Scott who has been closely associated with it throughout. Also I would like to acknowledge the help given me by Dr F. H. Kemp, Radiologist to the Wingfield-Morris Orthopaedic Hospital.

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TUBERCULOSIS TRANSMITTED BY BANKED BONE

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The use of banked bone is becoming general; there are few published reports of complications. At many hospitals an adequate supply of bone has proved difficult to obtain, and the use of ribs removed at thoracoplasty for pulmonary tuberculosis has become common. Theoretically it has seemed a safe procedure and Hausmann (1951) and Marsh and Barton (1952) have supported this after examination of rib marrow. Hausmann examined ribs from sixty-nine thoracoplasty stages by direct smear of rib marrow, and by culture of rib marrow and surface cultures: in all cases these were negative. Marsh and Barton examined the marrow from ribs on sixty-six specimens by direct smear and culture, and again in all cases there was no evidence of acid-fast bacilli.

During the last year ribs from thoracoplasties performed in cases of pulmonary tuberculosis have been stored in the bone bank. The ribs have been frozen at −15 degrees Centigrade to −20 degrees Centigrade in a solution containing penicillin and streptomycin. They have been used in a wide variety of orthopaedic procedures. In the last months four tuberculous abscesses have been discovered. After removal of the infected bone chips and curettage, the wounds have healed without further incident; it is, however, possible that further manifestations may appear. This unfortunate sequel makes it obvious that such material is unsuitable for bone graft.

CASE REPORTS

Case 1.—First and second stage spine fusion for scoliosis. Two weeks later the wound broke down. Two months after the first stage pleurisy developed, with a swinging temperature for three weeks. An enlarged axillary gland appeared and biopsy of this showed tuberculosis. Sequestrectomy and curettage of the wound followed by primary suture led to healing. Direct smear and culture from the wound confirmed tuberculosis. Streptomycin and isonicotinic hydrazide were given for three months.

Case 2.—One-stage fusion for scoliosis. Some weeks after operation two small sinuses developed; these persisted, and four months after operation curettage was performed. Each sinus led into a short track containing caseous material, but no dead or exposed bone was found. The caseous material was confirmed as tuberculous by culture and histological examination. Both sinuses healed immediately without chemotherapy.

Comment.—There were several common donors for Case 2 and the second stage of Case 1.

Case 3.—First stage fusion for scoliosis. The wound became infected (clinically an infected haematoma); the collection was drained. Ten weeks later the wound was still draining and an enlarged axillary gland was found. Acid-fast bacilli were found in the wound. Sequestrectomy was performed and primary suture carried out. The wound has almost healed in two weeks. Streptomycin and isonicotinic hydrazide have been given.

Case 4.—One-stage fusion of eight vertebrae. The wound healed by primary intention but three months after the operation a small sinus appeared; this remained small. Six months after operation sequestrectomy was performed, a few granulations were removed and two small bone chips which were lying loose were picked out. The wound healed immediately after the operation. Section of the granulation tissue showed typical tuberculosis. There were at no time any general symptoms or signs.

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CONGENITAL KYPHOSIS

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Of the conditions resembling tuberculosis of the spine congenital kyphosis is the least well known. In English literature it has been briefly described only by Brailsford (1948), Fairbank (1951) and Ferguson (1949). Long articles on the subject have, however, been published by Dutch, French, German and Italian writers (Van Assen 1930, Lombard and Le Génissel 1938, Saidman 1948, Bauer 1933, Lindemann 1931, Müller 1931 and Schapira 1936). The aim of this paper is to give an account of congenital kyphosis based on a study of three cases and a survey of the literature.

CASE REPORTS

Case 1. *Absent first lumbar and rudimentary twelfth thoracic vertebral body.*—A well built girl of fourteen years had a painless thoraco-lumbar kyphosis (Fig. 1). There were no other symptoms or signs. Her height was fifty-eight inches (slightly below the average). The deformity was noticed in infancy (Fig. 2). From five to ten years of age she was treated for tuberculosis of the spine: she spent three years on a plaster bed and subsequently wore a plaster jacket which she discarded at nine years of age. There was no family history of skeletal deformity. Her mother died of pulmonary tuberculosis.

Radiographic examination.—Figure 2 is a tracing of a radiograph of the spine taken when the patient was ten months old. The body of the first lumbar vertebra is missing and the body of the twelfth thoracic is rudimentary, but the pedicles and spinous processes of these two vertebrae are present. Figure 3 is a radiograph taken when the patient was fourteen years old. The kyphosis has increased, the twelfth thoracic vertebral body is hardly recognisable, the eleventh thoracic articulates with the second lumbar body and osteophytes have formed. Antero-posterior projections showed absence of the twelfth left rib and spina bifida of the second sacral segment. The rest of the skeleton was normal.

Case 2. *Rudimentary eleventh and twelfth thoracic vertebral bodies.*—A well built girl of eight years had a painless lower thoracic kyphosis (Fig. 4). She had no other abnormalities. Her height was fifty-one and a quarter inches (normal). She had been under observation for over five years. There was nothing of note in the family history.

Radiographic examination.—The eleventh and twelfth thoracic vertebral bodies were rudimentary, but the pedicles and spinous processes were normal (Figs. 5 and 6). There was a spina bifida of the first sacral segment. The rest of the skeleton was normal.

Case 3. *Absence of body of second lumbar vertebra.*—(Reported by courtesy of Mr V. H. Ellis.)—A baby girl of five months had a marked but correctable angular kyphosis in the upper lumbar region. There was no evidence of rickets or paralysis. In spite of a brace the deformity progressed and it did not disappear on extension or increase on flexion when the child was fifteen months old. Figure 7 shows the deformity at two years. The child had no symptoms at the age of four years and her height was thirty-seven inches (slightly below the average). The mother's sister and the father's father died of pulmonary tuberculosis.

Radiographic examination.—At two and a half years the second lumbar vertebral body was rudimentary, but the pedicle and spinous process were present (Fig. 8).

DISCUSSION

There are two types of congenital kyphosis: the first is associated with widespread disturbance of ossification, and is seen in chondro-osteo-dystrophy, gargoylism, cretinism and achondroplasia; in the second the kyphosis is due to localised malformation of the spine and the rest of the skeleton is normal. The second type will alone be discussed in the succeeding paragraphs.

Sex incidence.—In Van Assen's (1930) series of eighteen cases the sexes were affected equally; but if additional published cases are considered the deformity is commoner in females.

Etiology.—The cause is unknown. Except for two brothers with lumbo-dorsal kyphosis (Van Assen 1930) no familial examples are known.

FIG. 1

Case 1.—Appearance of spine at the age of fourteen.

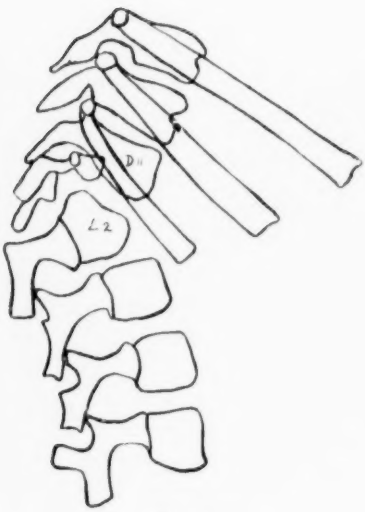

FIG. 2

FIG. 3

Case 1. Figure 2.—Tracing of a print from a radiograph taken when the child was ten months old. Note absence of the body of first lumbar vertebra and microspondyly of the twelfth thoracic vertebra; the pedicles are present. (Print kindly lent by Sir Thomas Fairbank.) Figure 3.—Radiograph taken at fourteen years. The kyphosis has increased. The twelfth thoracic vertebra is hardly recognisable; the eleventh thoracic vertebral body articulates with the second lumbar.

FIG. 4

Case 2.—Appearance of spine at the age of eight years.

FIG. 5

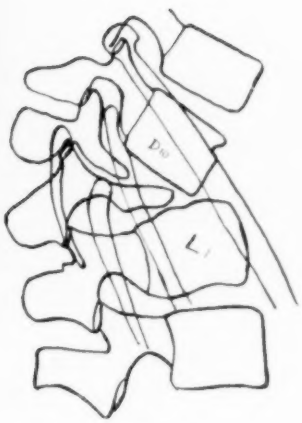

FIG. 6

Case 2. Figure 5.—Radiograph of lower thoracic and lumbar spine. Figure 6.—Tracing of Figure 5.—Note notch in anterior border of tenth thoracic vertebra and rudimentary eleventh and twelfth vertebral bodies.

Clinical features—The kyphosis at the thoraco-lumbar junction is usually noticed in childhood. It may increase as growth proceeds (Case 1), but it is painless in childhood and adolescence. Pain may arise later in life when osteoarthritic changes develop. Height is generally slightly below normal. Intelligence is not as a rule impaired; only one of Van Assen's patients was of low intellect. The deformity has been reported in association with

FIG. 7

FIG. 8

Case 3. Figure 7—Appearance of spine at age of two years. Figure 8—Radiograph taken at age of two and a half years. The second lumbar vertebral body is absent but the pedicles and spinous process are present. Note notch in first lumbar vertebra.

FIG. 9

FIG. 10

FIG. 11

Figure 9—Incomplete segmentation of three contiguous neighbouring vertebrae (Van Assen). Figure 10—Absence of a corner of a vertebra (Van Assen). Figure 11—Wedged vertebra in lateral view and butterfly appearance of same vertebra in antero-posterior view (Müller).

scoliosis (Müller 1931), rickets (Van Assen 1930), pes cavus (Van Assen 1930) and malformation of the ears (Van Assen 1930).

Complications—There are only two. The first, osteoarthritis, has already been mentioned. The other is damage to the nervous system. This has been recorded in a quarter of the published cases. One of Bauer's (1933) patients had a positive Babinski sign. Van Assen

(1930) described a patient with flaccid paralysis of the legs and another with paralysis of the interossei of the feet and bladder insufficiency. Lombard and Le Génissel (1938) demonstrated compression of the spinal cord by opaque myelography. The natural history of the disturbance of the spinal cord or cauda equina is unknown, because most of the patients reported so far were adolescents and were not followed up long enough.

Radiographic features.—There may be up to five abnormal vertebrae (Van Assen 1930). The kyphosis has been observed between the fourth thoracic and the fourth lumbar vertebrae, but its commonest site is between the tenth thoracic and the second lumbar. The defect may consist in: 1) absence of the body of the vertebra (Case 3); 2) absence of the body of the vertebra associated with microspondyly of a neighbouring vertebra (Case 1); 3) microspondyly of one vertebra (Saidman 1948); 4) microspondyly of two neighbouring vertebrae (Case 2); 5) incomplete segmentation of neighbouring vertebrae (Fig. 9); 6) absence of a corner of a vertebra (Fig. 10); and 7) wedging of a vertebra in the lateral view which is associated with a butterfly appearance in the antero-posterior view (Fig. 11). A notch is sometimes present in a vertebra above the kyphosis (Cases 2 and 3).

Differential diagnosis.—Difficulty arises only with tuberculosis (there was a family history of tuberculosis in Cases 1 and 3). If a patient with a thoraco-lumbar kyphosis has a consistently normal pulse and temperature and a normal blood picture, and if the radiographs show one of the abnormalities described above without osteoporosis, destruction of bone or disc, or paravertebral abscess shadow, the diagnosis of congenital kyphosis is probably correct.

Treatment.—According to Bauer (1933) the deformity cannot be corrected by conservative measures. Operative correction has not yet been reported, but in cases in which the body of a vertebra is completely missing resection of the spinous process and the lamina in childhood is a tempting proposition, because their presence is responsible for the deformity. Later in life pain from osteoarthritis may call for physiotherapy, supports, or even a local spinal fusion.

Minor degrees of paralysis do not require treatment. However, should severe symptoms, such as inability to walk, flexor spasms, trophic ulcers or retention of urine, develop, and spinal manometry and myelography show a spinal block, laminectomy and decompression of the spinal cord by longitudinal and transverse incisions of the dura without damaging the arachnoid are indicated. This may cause instability of the spine, but spinal fusion should only be carried out after an interval if demanded by increasing deformity or paralysis.

SUMMARY

1. Three cases of congenital kyphosis at or near the thoraco-lumbar junction are reported.

2. The features of the deformity are discussed.

It is a pleasure to record my indebtedness to Sir Thomas Fairbank for the help he has given me, to Mr V. H. Ellis for allowing me to include the third case, to Mr G. B. Northcroft for advising me on the treatment of the neurological complications, and to Dr J. Smitham for the drawing reproduced in Figure 6.

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MESENCHYMOMA (ANGIOLIPOSARCOMA) OF THE THIGH

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The term mesenchymoma was first applied by Gilmour (1943) to an unusual recurring tumour composed of embryonic connective tissue. The tumour he reported appeared histologically benign, but recurrences developed after every attempt at local removal. Since then, three more cases of a similar character have been collected and described by Symmers and Nangle (1951), who also recorded the fatal termination of Gilmour's case.

We now report two cases of mesenchymoma each occurring in the thigh of a female patient. They are compared with the four previously described.

CASE REPORTS

Case 1—A woman aged forty-seven noticed pain and swelling of the right thigh just above the knee. The swelling gradually increased and became more painful and interfered with movement of the knee and with walking. She did not attend for advice until two and a half years after the onset of symptoms. *On examination*, the patient's general health was satisfactory and she had recently gained weight. Temperature and pulse were normal. The front of the right thigh was greatly enlarged by an ovoid, smooth, tender swelling extending from the upper border of the patella into the upper third of the thigh (Fig. 1). The skin was tightly stretched over the tumour and many dilated veins could be seen; the swollen limb felt warmer than the unaffected thigh. The tumour did not involve the skin but was fixed to the deeper structures. Fluctuation was not elicited. There was an effusion into the right knee joint. Flexion of the knee was limited to 40 degrees. No palpable lymph nodes were discovered in the groin or abdomen. The liver and spleen were not palpably enlarged. *Radiographs* of the thigh showed a large soft-tissue shadow, extending mainly in the long axis of the limb and occupying the quadriceps compartment of the thigh. There were no areas of calcification. The femur itself appeared normal. Radiographs of the chest were normal. The erythrocyte sedimentation rate was 32 millimetres in one hour (Wintrobe). Haemoglobin was 75 per cent. The Wassermann and Kahn reactions were negative.

A fibrosarcoma involving the quadriceps muscle was suspected. Biopsy was undertaken. A thinned-out layer of apparently normal muscle was first encountered and deep to this a greyish glistening capsule. The swelling was aspirated and a grey jelly obtained; a specimen of this material was then taken with a spoon. Culture of a swab taken from the wound was sterile. Sections of the material obtained were reported as fragments of a mesenchymoma.

Treatment—Because of the known tendency of this tumour to recur after incomplete removal and to grow more rapidly, amputation was advised. Since the tumour had already extended well up the thigh, and was diffusely involving the quadriceps muscle, the limb was removed by disarticulation at the hip joint, all the muscles being divided as high as possible. One year after the operation the patient was in good health and there was no sign of recurrence of the tumour.

Histology of the specimen—Macroscopically, the tumour was ovoid and soft, and measured 19 centimetres by 6 centimetres by 15 centimetres. It was partly surrounded by a thin diaphanous capsule. On gross section the tumour was found to be separated into lobules by fibrous septa. The cut surface was glistening and greyish white (Fig. 2). The tumour, which encircled the femur for almost three-quarters of its circumference, extended upwards from the knee joint as far as the uppermost limits of the vastus intermedius. Although it was mainly confined to the quadriceps group, it involved also the insertion of the adductor muscles into the shaft of the femur.

Microscopically, the tumour was similar to those described by Symmers and Nangle, and consisted of three main varieties of tissue: angioblastic, fibroblastic and lipoblastic. The vascular and fibrous components were blended and formed lobules of varying size. The adipose tissue varied from immature lipoblasts to adult fat cells and was mainly found between the vasculo-fibrous lobules. The cells were seen to be spreading along and invading the capsule and fibrous septa. Mitoses were not numerous (Figs. 3, 4 and 5).

Case 2—A woman aged fifty noticed a swelling along the lower postero-medial aspect of the right thigh which grew slowly for two years before she sought advice on account of a more rapid

FIG. 1

Case 1.—Clinical photograph of affected limb after biopsy.

FIG. 2

Case 1.—The tumour in situ and bisected in the long axis of the limb. The capsule, lobules and septa are shown.

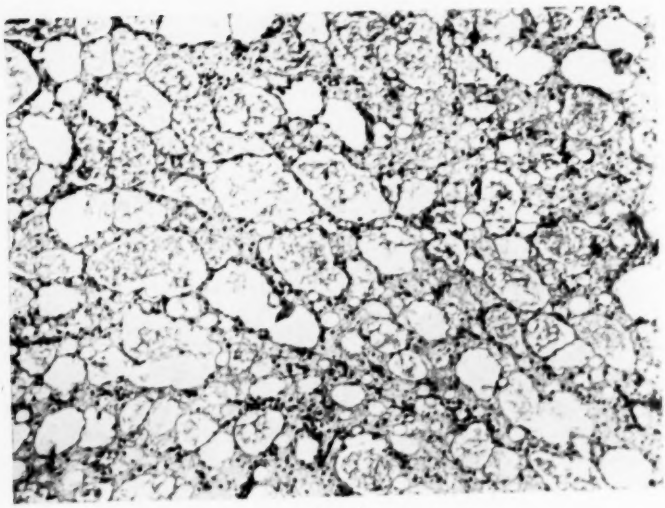

FIG. 3

Case 1.—Sections showing an area of many mucinous cysts interspersed with lipoblasts (H. and E. × 68).

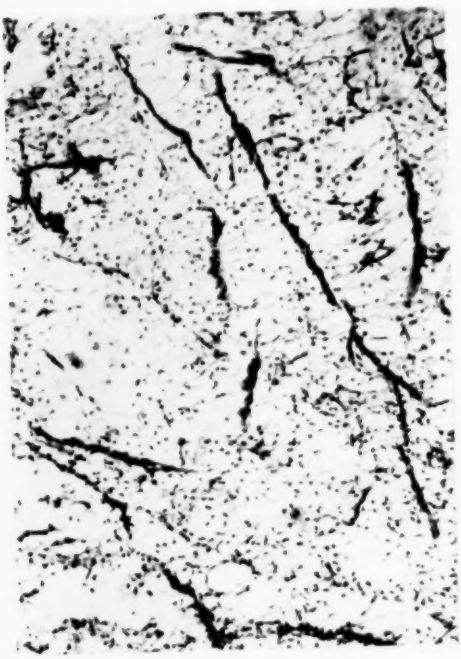

FIG. 4

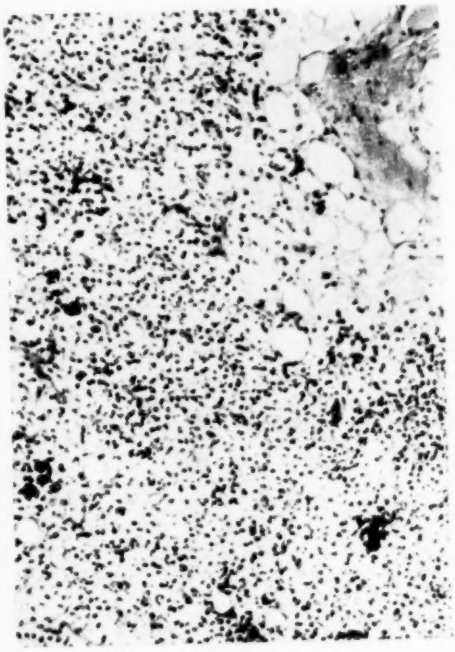

FIG. 5

Case 1. Figure 4.—Tumour tissue showing a mixture of angioblastic and lipoblastic tissue. Some primitive vascular channels are seen (H. and E. × 74). Figure 5.—Section showing groups of cells resembling nucleated red blood cells in the midst of characteristic mesenchymatous tissue (H. and E. × 112).

increase in size. There was no sharp pain but an ache was complained of after use. *On examination*, an oval swelling occupied the postero-medial aspect of the right thigh just above the knee. It was well circumscribed, but it was attached to deeper tissues. It was not tender. *Radiographs* showed a soft tissue swelling in the thigh without any bone changes; there was no evidence of secondary deposits in the chest.

Treatment—The mass was treated at another hospital by an extensive local excision. The tumour was found lying deeply in the adductor canal; there was no obvious capsule. It did not appear to arise from any particular structure. Microscopically, the tumour was found to be a mesenchymoma. Sections of the specimen removed resembled closely the histological appearance in Case 1.

Progress and further treatment—The immediate post-operative course was uneventful, but one year later a recurrence of the tumour was observed. A lump four centimetres in diameter appeared in the centre of the old scar. The mass was removed together with the fascia of the surrounding muscles. There was a further recurrence one year later; local excision was again undertaken. There was yet another local recurrence nine months later, again treated by excision.

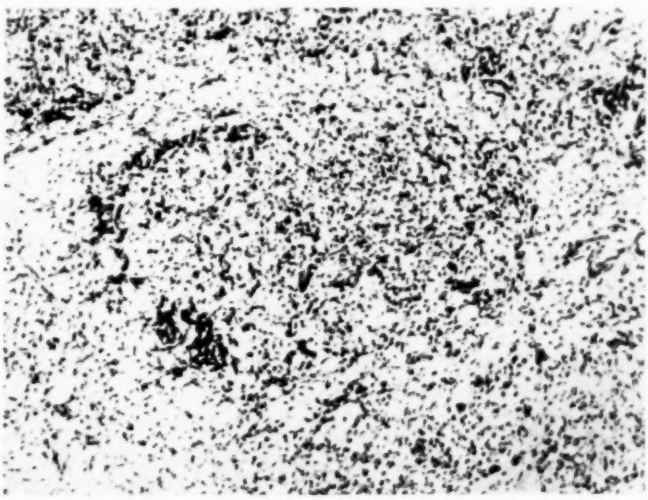

FIG. 6

Case 2. Sections from a second recurrence removed two years after the first local excision. A central cellular area of sarcomatous appearance is seen surrounded by original tumour tissue (H. and E. × 89).

The specimen removed at the third operation showed the tumour to be involving the sartorius muscle, and histologically it presented a more primitive and active picture than before (Fig. 6). At the fourth operation it was obvious that the tumour was infiltrating the surrounding tissues. Amputation was therefore undertaken four years after the onset of symptoms and three years after the first local excision. The limb was severed well above the site of the highest recurrence. One year after operation there was no evidence of a return of the lesion.

DISCUSSION

Ewing (1940) described a "foetal or embryonal myxo-liposarcoma." The term "mesenchymoma" was first applied to this type of tumour by Gilmour (1943). The term mesenchymoma as applied to this particular tumour is thought to be appropriate because of the resemblance of the primitive fibroblastic component of the tumour to mesenchymal tissue. Angiomatous and lipomatous elements are also present and the tumour is at least locally malignant.

Confusion in terminology may arise because the term mesenchymoma has also been applied to other tumours such as myxomas, mixed malignant tumours of mesodermal origin

TABLE I

SIX CASES OF MESENCHYMOMA

Case number	Author	Age at first occurrence (years)	Duration of symptoms before treatment	Sex	Site of tumour	Treatment and results so far as known
1	Pemberton and Cromack (1953)	44	2½ years	F	Thigh	Disarticulation at hip, which included the origins of quadriceps and adductor muscles. No recurrence to date (one year)
2	Pemberton and Cromack (1953)	48	2 years	F	Thigh	Three local excisions with recurrence after each at shorter intervals. Amputation through mid-thigh. No recurrence to date (one year)
3	Symmers and Nangle (1951)	34	1½ years	M	Thigh	Local removal. Recurrence in 1 year. High amputation. Malignant ascites and death. No necropsy
4	Symmers and Nangle (1951)	39	3 years	F	Thigh	Local removal. Recurrence in 14 months. High amputation. No known recurrence
5	Symmers and Nangle (1951)	23	1 year	F	Lumbar muscles	Local removal. Multiple recurrences. Excision and radiotherapy. Death 23 years after first excision
6	Symmers and Nangle (1951)	47	2 months	M	Buttock	Local removal and radiotherapy. Three subsequent recurrences. Hind-quarter amputation. Recurrence. Death 4 years after original excision

(Stout 1948), and even to undifferentiated sarcomata (Klein 1932). There is no doubt that the two cases presented here conform to the pattern of Gilmour's case to which he applied the description mesenchymoma.

The clinical picture is that of a locally malignant recurring tumour and in three of the cases (Table I) so far recorded death eventually resulted, although there was no firm evidence of metastatic deposits in any of these three fatal cases. It is felt that since recurrence seems invariably to follow local removal a relatively drastic surgical policy is justifiable and indeed necessary in the treatment of this type of tumour. If the locally invasive properties of the tumour are confirmed at biopsy and the histological picture conforms to that of "mesenchymoma" the proper treatment is an amputation or disarticulation without any attempt at local excision.

For details of Case 2 we are indebted to Mr. A. G. Young of Hitchin. We wish particularly to thank Dr. J. T. Prendiville, Consultant Pathologist at Chase Farm Hospital, for his help in both cases.

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A PAROSTEAL LIPOMA

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The recent publication in the Journal of a case of lipoma causing a lesion of the posterior interosseous nerve (Richmond 1953) prompts me to report a similar case seen in 1927 in which the same nerve seemed to be involved, but without interference with its function.

Case report—A man of fifty-eight years complained of a lump on the outer side of his right forearm which he had noticed for the past three weeks. His only complaint was that for some time past, when playing the piano, his arm got tired. There was an obvious swelling on the outer side of the forearm in the upper third. The swelling was firm with a slightly irregular surface which was rather elastic in the middle but not actually fluctuant: below, the swelling ended rather abruptly. It was not tender. It was covered by the muscles and rotated with the radius. There were no large veins or other visible changes in the arm, and no paralysis. The radiograph showed a bilobed translucent area in the muscles beside a normal radius (Fig. 1), so a diagnosis of lipoma was made. At operation the tumour was found buried beneath the fibres of the supinator brevis muscle. As the position and direction of the deep groove in the surface of the tumour suggested that this was produced by the posterior interosseous nerve it was decided that it would be wiser to leave this part of the capsule intact. The lipoma was divided a little below this groove, and removed in two parts, the upper being slipped from beneath the nerve without difficulty. A few outlying nodules of fat were found lying posterior to both lobes of the main tumour. The periosteum covering the radius was intact. Examination of the forearm later revealed no sign of nerve damage.

Fig. 1

Radiograph showing the bilobed radio-translucent tumour adjacent to the upper third of the radius.

Comment—Parosteal was the term used by D'Arcy Power in 1888 when he reported a case of lipoma growing beside a femur. In his book on Tumours, Bland-Sutton (1906) cited fourteen cases, including three of his own, of "parosteal lipomata" which he regarded as "arising from the periosteum." In only one of these cases was the radius the bone involved (Smith 1868). This was in a boy of nine years with a lump the size of a man's fist which had been growing for six years: on removal of the tumour the neck of the radius was bare and "beset with minute spicules." No mention is made of any paralysis. Parosteal seems preferable to periosteal as applied to these lipomata, and both terms seem to be more accurate than subperiosteal.

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A CASE OF TUBERCULOSIS OF THE ISCHIUM

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Formerly Orthopaedic Registrar, Royal Portsmouth Hospital.

Tuberculous infection of the ischium is rare. Between the years 1901–1936 only seven cases were reported, all in French (Coeuilliez 1909, Sorrel and Sorrel-Dejerine 1932). In 1936 Kaplan described the first case in English, and later Magnusson (1938) reported further cases, also in English, from Sweden. He reported eight cases of osteitis of the ischium treated at Varberg between 1928–1936, seven in adults and one in a child aged six years. Five of these cases were, however, of uncertain etiology. Magnusson assessed the incidence of tuberculosis of the ischium as 0·2 per cent of all cases of bone tuberculosis.

All the above authors drew attention to the insidious onset and invariable previous gluteal injury. Unexplained sciatic pain was often the first symptom.

For extensive lesions, Milch (1935) of New York described excision of the ischium and its ramus by subperiosteal resection from the perineum.

CASE REPORT

A girl aged twenty years, a costing clerk, reported to her doctor complaining of an aching pain in the groin. The pain was of gradual onset and was present both during activity and at rest, but more particularly on walking. She had been treated for epilepsy, but otherwise had been quite healthy; there was no family history of tuberculosis. She had fallen on to the buttock nine months before. Radiant heat and massage afforded relief for three months. A month later she complained of pain in the back of the upper thigh and found that flexion of her right hip caused discomfort. She stated also that she was able to walk more comfortably in high-heeled shoes. She carried on without treatment for a further eight months, after which she again sought advice for a gradually enlarging swelling in the buttock. She also complained of a burning pain in the right buttock on sitting. She was admitted to hospital.

On examination the swelling, four inches in diameter, was found to be warm and fluctuant, and extended upwards deep to the gluteus maximus. There were no local skin colour changes. There was no tenderness or spasm in the thoracic or lumbar spine, whose movements were free, nor was there any other tender point. Abdominal and rectal examination revealed nothing abnormal, and chest examination revealed no clinical abnormality, but radiographs showed a healed lesion at the right apex. Radiographs of the spine, hips and sacro-iliac joints showed nothing abnormal, but there was a suspicious area of rarefaction in the right ischial tuberosity with evidence of sequestration (Fig. 1).

The diagnosis of tuberculous abscess was confirmed by the aspiration of 350 cubic centimetres of thin yellow pus containing acid-fast bacilli.

Treatment and progress.—The abscess filled up again and required further aspiration within four weeks. A sinus developed at the aspiration site after a week and continued to discharge profusely. Further radiographs of the right ischium a few weeks later showed a large cavity containing sequestra (Fig. 2).

After treatment by strict rest in bed, with restriction of leg movement by the means of sandbags, the sinus in the buttock gradually healed. But two months later a swelling appeared in the perineum; this broke down in twenty-four hours and discharged pus profusely. The abscess had apparently tracked forwards through the ischio-rectal fossa. A course of penicillin

FIG. 1

Initial radiograph of ischium showing an area of rarefaction and sequestration within.

FIG. 2

Figure 2.—Two months later. A cavity with sequestrum within can be seen.

FIG. 3

Figure 3.—Two months after operation. The lesion appears to be healing.

FIG. 4

Drawing made at operation showing the appearance of the lesion (top) and two views of the sequestrum (actual size).

and sulphamezathine was started to deter secondary infection, and the discharge decreased. Radiographs showed no further bone destruction. Since the serial blood sedimentation rates had remained stationary, operation was undertaken. The right ischial tuberosity was explored through Henry's gluteal approach, under streptomycin cover. When the gluteus maximus was reflected pus was located tracking down to the ischial tuberosity. The surface of the bone was necrosed on its inferior aspect, and a loose sequestrum was found plugging a cavity three-quarters of an inch in diameter (Fig. 4). This and two further sequestra were removed and the cavity in the ischium was curetted. The wound was closed round a tube passed to the site of the lesion. Local streptomycin was instilled into the tube (0·5 gramme twice daily) for four days. The systemic streptomycin (0·5 gramme twice daily) was continued for ten days. The wound healed by first intention, and convalescence was uneventful. Radiographs two months after operation suggested that the lesion was healing (Fig. 3). The patient remains well one year after operation, and there are no symptoms.

My thanks are due to Mr A. G. Ord for permission to publish this case and to Miss Thomson for the drawing and radiographs.

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PARATHYROID OSTEODYSTROPHY

Report of a Case

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A woman of sixty-nine was admitted with a fracture of the neck of the left femur (Fig. 1) sustained while she was mounting the stairs in her home. Her subsequent clinical course prompted a careful inquiry into her history.

From the age of twenty she had suffered from recurrent attacks of indigestion, haematemesis, anaemia, tiredness, vague pains in her bones and swelling of the ankles. Certain events stood out clearly in her memory. At the age of forty-nine she fell downstairs injuring her back, as a result of which she was confined to bed for approximately two years and developed a kyphosis. At the age of sixty she noticed that her legs below the knees became swollen and she also experienced aches and pains in her bones, particularly in her back. At sixty-six she suffered from a severe attack of indigestion associated with vomiting, upper abdominal pain and haematemesis. At that time the abdomen was explored for suspected carcinoma of the stomach: no gastric neoplasm was found but a uterine fibroid and a cyst of the ovary were removed. Thereafter she developed quite severe pains in her bones, which continued until the time of her admission.

Fig. 1

Initial radiograph showing fracture of the femoral neck and osteoporosis of the upper end of the bone.

Progress. During the routine manipulation to reduce the fracture of the femoral neck a spiral fracture of the shaft of the femur was produced. At the subsequent nailing operation it was noted that the bone was abnormally soft. A biopsy was taken but the pathological examination showed no conclusive findings.

Investigations. The blood calcium was 11·3 milligrams per cent, phosphorus 2·9 milligrams per cent, alkaline phosphatase 25 units. Blood picture was normal except for diminished haemoglobin value (70 per cent). Blood urea was 30 milligrams per cent and plasma proteins 6·5 grammes per cent. Urine consistently contained Bence-Jones protease and a trace of albumen. Two sternal punctures gave films suggestive of multiple myelomatosis. Further biopsy of one tibia was inconclusive.

Further investigations three months later showed that the blood calcium had risen to 13·6 milligrams per cent. Complete radiographic examination revealed generalised osteoporosis with cystic changes in several bones (Figs. 2 to 7). Biopsy of one tibia showed changes

Fig. 2
Right tibia

Fig. 3
Right humerus

Fig. 4
Left radius and ulna

Fig. 5
Skull

FIG. 6
Spine.

FIG. 7
Left hand.

FIG. 8

FIG. 9

Figure 8.—Section from tibia showing spicules of bone with many giant cells and much fibrosis. (×240)
Figure 9.—Another area. Numerous spicules of bone, some of which appear to have been splat by fibrous tissue. (×240)

consistent with osteitis fibrosa cystica (Figs. 8 and 9). Bence-Jones proteose was still present in the urine.

Treatment—The neck was explored and a large tumour of the right superior parathyroid gland was removed (Fig. 10). Macroscopically, the specimen showed general hyperplasia of

FIG. 10

The parathyroid tumour removed from the neck. The scale is marked in centimetres.

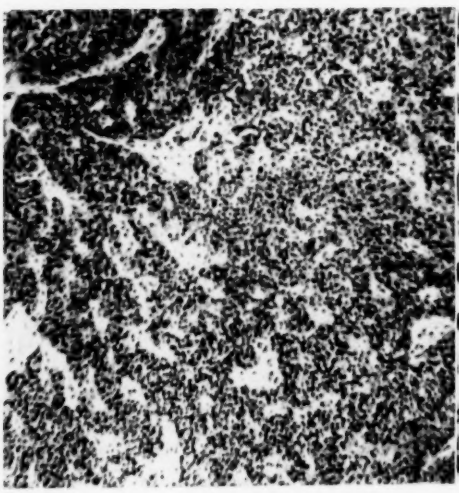

FIG. 11

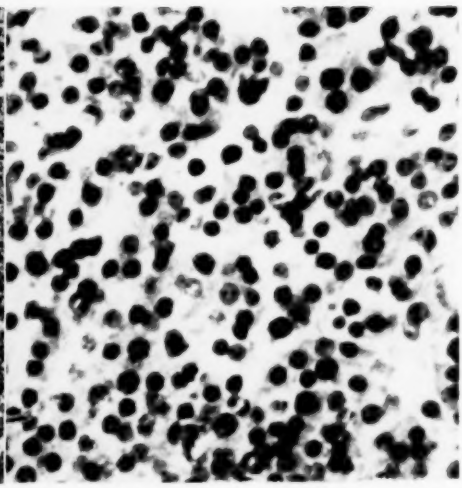

FIG. 12

Figure 11—Photomicrograph of a section of the parathyroid tumour (×60). Figure 12—A section of the tumour seen in higher magnification (×530).

the gland without evidence of a localised adenoma. Microscopically, the cells were all of a pale, oxyphil type. There were a few cells with exceptionally large hyperchromatic nuclei (Figs. 11 and 12).

Later progress.—Four days after operation, Bence-Jones proteose disappeared from the urine. On the eighth day she developed a severe attack of tetany which was controlled with some difficulty with calcium lactate, calcium gluconate and calciferol.

When the patient was last reviewed two years and three months after operation she had made good progress: the fractures of the femur had united, and the cystic lesions of the bones had filled in, but considerable osteoporosis was still present. She was in good health and walked with the aid of a stick.

DISCUSSION

Although the diagnosis of parathyroid osteodystrophy was suspected at the time of the nailing operation the serum calcium was at that time within normal limits and there were a number of unusual features that threw doubt on the validity of that diagnosis. It seems possible that the history extended back forty-nine years to the time when the patient first developed symptoms of aches and pain in her bones, anaemia, and symptoms of peptic ulceration at the age of twenty. There were also four periods when her symptoms were definitely worse: first, the onset mentioned above; second, when at the age of forty-nine she fell and hurt her back and was in bed for two years and developed a kyphosis of the spine; third, when severe oedema of the legs below the knees developed at the age of sixty; and fourth, when she was admitted to hospital for laparotomy for suspected carcinoma of stomach. At these times, the pains in the bones were particularly bad, although she was a little vague about their severity at the time of onset of symptoms forty-nine years ago.

Norris (1947) from a review of 322 cases published in the literature, concluded that the duration of parathyroid osteodystrophy was much longer than was generally realised and reported one case of thirty-nine years' duration. He also observed that in some cases there appeared to be periods in the course of the disease in which the severity of the symptoms was increased. Further, the obstinate anaemia from which the patient suffered fits in with Rienhoff's (1950) observation that anaemia is common in all conditions in which hypercalcaemia is present. Gastric and duodenal ulcers in association with hyperparathyroidism have been reported by Rogers *et al.* (1947) and Black and Ackerman (1950). The presence of Bence-Jones proteose in the urine was reported by Snapper (1949).

This was my first contact with a case of hyperparathyroidism and the features which were at first rather confusing became clearer as the investigations were continued and the literature surveyed. Since approximately 40 per cent of parathyroid tumours present themselves as generalised osteitis fibrosa cystica (Hoffmann 1952), it is hoped that this case report may help to draw attention to some of the less common or less recognised features of the condition.

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OSTEOARTHRITIS OF THE HIP: A STUDY OF THE NATURE AND EVOLUTION OF THE DISEASE

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From the Nuffield Orthopaedic Centre, Oxford

Despite the efforts of many workers to increase our understanding of osteoarthritis, effective measures have been devised only for the treatment of the advanced stage of the disease; such treatment usually involves either the total suppression of the affected joint by arthrodesis or the more or less complete removal inherent to arthroplasty. The vogue acquired by these operations proclaims our failure to arrest, and even more to reverse, the progress of the disease before the joint has been completely disorganised, a process which entails prolonged suffering and frustration.

The investigation here reported was initiated under the belief that, as has happened in other conditions, a better understanding of the problems involved might lead to new therapeutic advances. We were conscious from the beginning of the skill and authority of those who had preceded us in the study of osteoarthritis but the persistence of many conflicting views and important gaps in the knowledge on fundamental points seemed to justify further work. Many previous investigations have been directed to the tissue changes produced by the disease and, as methods of research have become increasingly refined, the pathological studies have also been made more penetrating, the study of the cell giving place to that of the molecule. Surgeons, however, have the unique opportunity of seeing the disease as it affects the joint as a functional whole and not as an ailment of a particular tissue such as cartilage, bone, capsule, synovial membrane or synovial fluid.

TABLE I

Age Distribution of Femoral Heads Examined Post-mortem

Age of subject at time of death (*years*)	Number of femoral heads
0 — 10	8
11 — 20	5
21 — 30	0
31 — 40	3
41 — 50	2
51 — 60	12
61 — 70	13
71 — 80	22
81 — 90	11
91 — 100	9
Unknown (adult)	3
Total	91

We have selected the hip because it is the commonest clinical site of severe osteoarthritis and the investigation has embraced not only the disorganised joint of the final phase of the disease but the various stages of its evolution from the normal. Our description is limited, largely by considerations of length, to the femoral head; we have found that the changes in the acetabulum are similar and like mirror images of those occurring in the other member of the articulation.

In the pages that follow we bring the results of our analysis mainly for the consideration of our surgical colleagues who are daily confronted with the responsibility of treating patients suffering from osteoarthritis of the hip.

MATERIAL

This investigation is based upon the following human material: 1) Ninety-one post-mortem examinations of the hip. This material, analysed in Table I, showed all variations from that of normal health to advanced osteoarthritis. 2) Forty-five femoral heads removed at operation from osteoarthritic hips. 3) Radiographs obtained from eighty selected patients suffering from osteoarthritis of the hip in whom it was possible to follow the progress of the disease over several years.

METHODS OF INVESTIGATION

The tissue studies reported below were made with particular reference to the region of the joint in which the lesions occurred: essentially it has been a correlation of pathology and joint topography, and the methods used were as follows.

Dissection and macroscopic examination—The post-mortem examination of hip joints permitted not only the collection of material but the observation of the site and the intra-articular relationship of the various pathological lesions.

Radiography—Radiographs in at least two planes at right angles to each other were made of all specimens. Many of the specimens were then sawn up into slices whose thickness and plane of section varied from specimen to specimen and these were then submitted to further radiography. The extent of cartilage lesions was frequently indicated by the insertion of radio-opaque markers into the cartilage prior to radiography.

Histology—Written and photographic record was kept of the exact area of the joint from which any material was taken for histological examination. Sections embedded either in paraffin or low viscosity nitrocellulose were stained by routine colorimetric techniques: haematoxylin and eosin, Van Gieson. Histological techniques using toluidine blue, colloidal iron (Hale) and periodic acid–Schiff (McManus) were employed for the investigation of the mucopolysaccharide content of the articular cartilage.

Investigation of the vascular pattern of the osteoarthritic femoral head—The methods of vascular injection and the radiographic, transparency and special histological techniques used in this study to demonstrate blood vessels within bone have already been described in a previous paper (Trueta and Harrison 1953). Histological examination of injected tissues has been of inestimable value in interpreting the vascular arrangements in sections cut from uninjected material.

SOME PRELIMINARY CONSIDERATIONS OF THE ANATOMY OF THE HIP JOINT

Before describing our pathological findings it is considered necessary to emphasise some anatomical features of the hip joint.

The human hip is classed as an enarthrosis or a ball-and-socket joint, but certain features of the acetabulum considerably reduce the implications suggested by this definition. With the exception of the fovea capitis the femoral head is entirely covered by hyaline cartilage; but the acetabulum is much less completely lined. There the cartilage has the shape of an inverted horseshoe between whose two limbs is the acetabular fossa (Fig. 1) which contains a pad of fat covered by synovial membrane. Such an arrangement of the acetabulum entails that in any position of the joint a considerable part of the surface of the head of the femur is opposed to the soft tissues filling the acetabular fossa and not to acetabular articular cartilage. This fact may be demonstrated in sections of fresh cadaveric hip joints. It ensures that a considerable area on the infero-medial surface of the femoral head is prevented by lack of articular contact from the transmission of joint stress. Such sections also demonstrate that anteriorly, superiorly and, to a lesser extent, posteriorly, the marginal articular cartilage of the femoral head tends to project laterally outside the acetabulum. Only in the very extremes of movement can most of this peripheral cartilage of the head be brought into articulation with the acetabular cartilage.

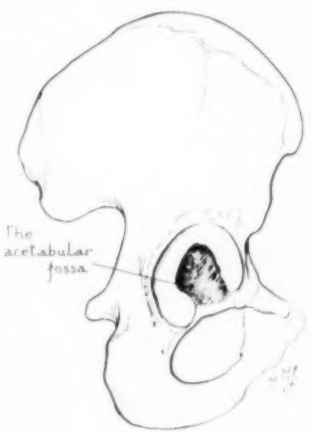

FIG. 1

Sketch of the right hip bone showing the extent of the articular cartilage and the acetabular fossa.

Throughout this article the articular cartilage on the head of the femur which in the normal ranges of movement articulates with the cartilage of the acetabulum will be

designated as occupying *the pressure area*; that which does not is termed the cartilage of the *non-pressure area*. The differentiation between the pressure and non-pressure areas on the surface of the head may be traced across into one of the main trabecular systems of the cancellous bone of the head. Before epiphysial fusion the spongiosa of the head has a close-mesh structure which permits little differentiation of individual systems. Nevertheless a band of trabeculae (*a*., Fig. 2), which it is desired to draw attention to in later decades, can already be defined in the metaphysis, running through the lower part of the femoral neck from the corticalis below, up towards the epiphysial plate. After fusion of the epiphysis this trabecular system can be traced upwards until it reaches the articular surface of the head in its superior part. A large range of variation exists, and it is not exceptional to find adolescent patterns of trabeculation even in later decades of life. The more typical of the trabecular patterns in adult femoral heads takes the shape of a column with its upper part spreading mushroom-like and which in frontal sections (Fig. 3) appears like a fan. We shall name this

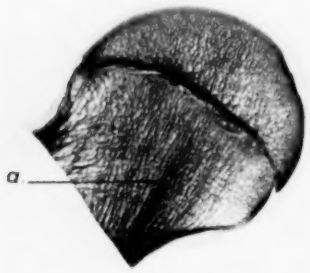

FIG. 2

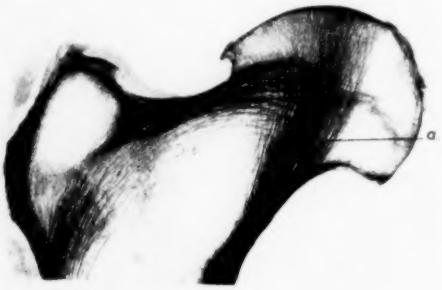

FIG. 3

Figure 2.—Radiograph of a coronal section from a femoral head, subject aged fourteen years. *a*.—bone trabeculae referred to in the text. Figure 3.—Radiograph of a coronal section from a femoral head, subject aged eighty-six years. *a*.—system of bone trabeculae referred to in the text.

group of trabeculae the *pressure system* because they are concerned with the transmission of forces from the trunk to the lower limbs and from the lower limbs to the trunk; indeed they can be traced into continuity across the joint with a group which runs within the ilium up towards the sacro-iliac joint. As indicated in Figure 4 the distribution of these trabeculae allows articular cartilage on the surface of any head to be subdivided into: 1) that which overlies the trabeculae of the pressure system; 2) that on the infero-medial aspect of the femoral head, medial to the pressure system; and 3) that at the edge of the femoral head, lateral to the pressure system. By studying hip joint specimens and slab radiographs subsequently obtained from them it is possible to show that the areas just described have the following significance. The cartilage which overlies the pressure system is that which articulates with the acetabular cartilage and therefore occupies the pressure area. The part of the cartilage infero-medial to the pressure system is that which faces the acetabular fossa and will be designated the *medial non-pressure area*. The cartilage lateral to the pressure system is that which projects externally out of contact with the acetabular cartilage. It will be designated the *peripheral non-pressure area*. The diagram in Figure 5 depicts a distribution of the pressure and non-pressure areas which is commonly present in the normal adult femoral head.

One final definition necessary for the description which follows is that of the *pressure segment*. By this we mean that portion of the femoral head traversed by the trabeculae of the pressure system.

At the time when this work was started it was found that no detailed description of the

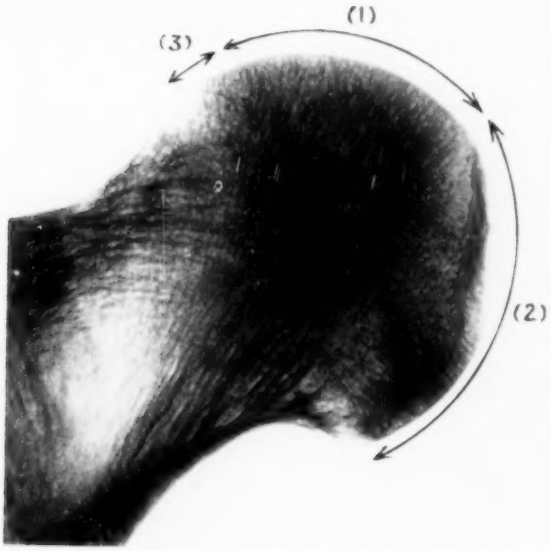

FIG. 4

Antero-posterior radiograph of a femoral head. The surface cartilage is subdivided, as described in the text, into areas (1), (2) and (3) relative to the pressure system of trabeculae.

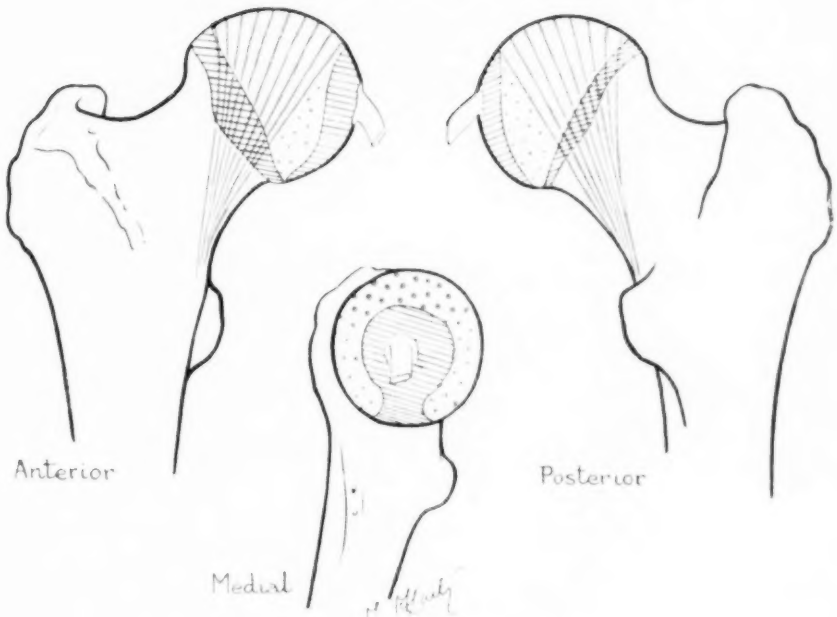

FIG. 5

Distribution of the pressure and non-pressure areas commonly present in the normal adult femoral head. Trabeculae of the pressure system are shown in red. Non-pressure areas are cross-hatched in black.

normal vascular pattern of the femoral head, based upon radiographic or photographic evidence, existed in the literature. Such information being necessary as a control material for the present study, the normal vascular anatomy was investigated and the results have already been published (Trueta and Harrison 1953).

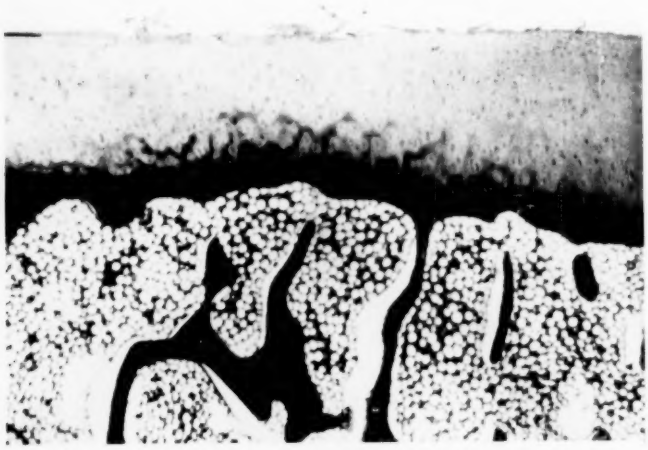

FIG. 6

The articular cartilage shows an early stage of degeneration with disruption of its superficial or tangential layer, *a*. (H. and E. × 22.)

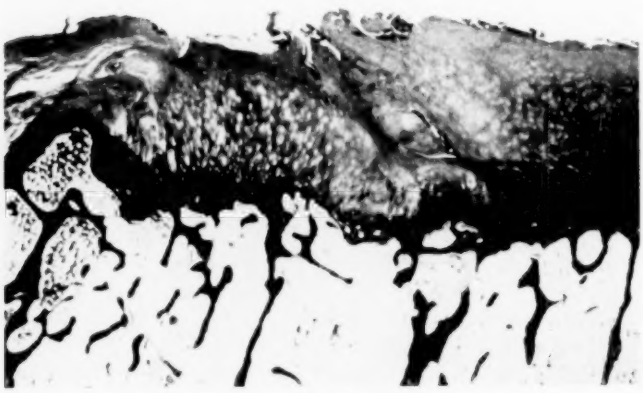

FIG. 7

Advanced stage of cartilage degeneration; the appearance of collagen fibres and fissuration is typical of the state of "fibrillation." (H. and E. × 10.)

Comment.—For the anatomical reasons presented above the hip affords excellent opportunities for a controlled investigation of the effects of stress and strain on the tissues of the joint and the distribution and thickness of the bone trajectories of the pressure system are an important guide to such a study.

In a comparative survey Walkhoff (1904) showed that this system is exclusive to the

adult human; none of the lower animals or apes, nor even the femoral head of the Neanderthal man, possesses it. The factor which appears to be responsible for the organisation of the pressure system is the locking of the hip joint in extension, an event inherent to the erect position peculiar to man. Without discussing the merits or otherwise of those theories which seek to explain the factors conditioning the internal architecture of bone there is considerable evidence to support those who, like Thoma (1907), Jansen (1920) and Carey (1921), attribute to pressure the role of directing the configuration of the spongiosa. Thoma (1907) showed that the determining role of pressure is bound up not only with the quantity of the load but also the period of time during which it is acting. It seems probable to us that the duration of weight bearing, habits of stance and the relatively restricted joint usage of adult life as opposed to those of youth and adolescence, may explain the tendency to increasing definition of the pressure system in the mature human. This concentration of the load explains the thinning of trabeculae in the lightly stressed segment of the head, particularly that part which is opposed to the acetabular fossa. As will become apparent in the following sections, a progressive evolution of the pressure system occurring in the hip joints of some adults appears to be incompatible with continued joint health.

RESULTS

The findings of this investigation are integrated and presented below as an account of the evolution of an osteoarthritic hip joint from a normal one. We believe that this is preferable to a detailed description of the isolated pathological data because therapeutic advances will probably be possible only when a complete understanding of pathogenesis has been achieved.

Without exception, in our material, the initiation of the osteoarthritic process took place in the articular cartilage. If the disease progresses, this initial stage is followed by osteophyte formation, flattening of the femoral head, eburnation, necrosis, sclerosis, cyst formation and extrusion of the head. These different phases of osteoarthritis will now be detailed.

The nature, frequency and distribution of the cartilage lesion—The earliest macroscopic change in the cartilage is the replacement of its normal, smooth, shiny surface by a mat irregular one which feels softer than normal when pressed upon by a probe. As the cartilage becomes further altered its surface continuity is lost and it presents a filamentous appearance; fragments of cartilage become separated and lie free in the joint cavity. Microscopically the early cartilage lesion consists of changes in the non-calcified part of the cartilage which result in the condition known as fibrillation (Figs. 6 and 7). Histochemically these changes are seen to be accompanied by a reduction in metachromasia of the cartilage.

Every femoral head examined post-mortem in subjects of fourteen years or over showed some area of cartilage which was suffering from the changes just mentioned. In the second decade the area of macroscopic cartilage degeneration was small, but beyond this age all grades of extent and severity were encountered (Figs. 8 and 9). An analysis of our post-mortem material from subjects aged fourteen to a hundred years showed that 71 per cent of femoral heads had cartilage degeneration confined to the non-pressure areas whereas in only 3 per cent was the same change restricted to the pressure areas. In the remaining 26 per cent the cartilage lesion was present in both areas. Figure 10 illustrates how the localisation of the affected cartilage was achieved.

The degree of cartilage degeneration is not uniform within the imprint of the acetabular fossa on any one femoral head. In some places circumscribed loss of cartilage produces ulcers, in others it is a diffuse velvety change which provides the contrast to normal cartilage. As shown in Figures 8 and 9 it is usual to find the rest of the cartilage—namely that of the pressure area—in an excellent state of preservation.

The term "ageing" is frequently applied to this cartilage degeneration but it must be emphasised that these changes are neither restricted to the elderly, nor could any direct

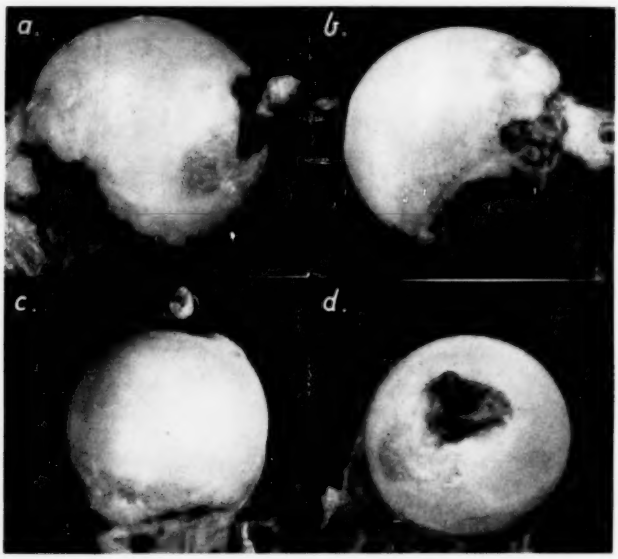

FIG. 8

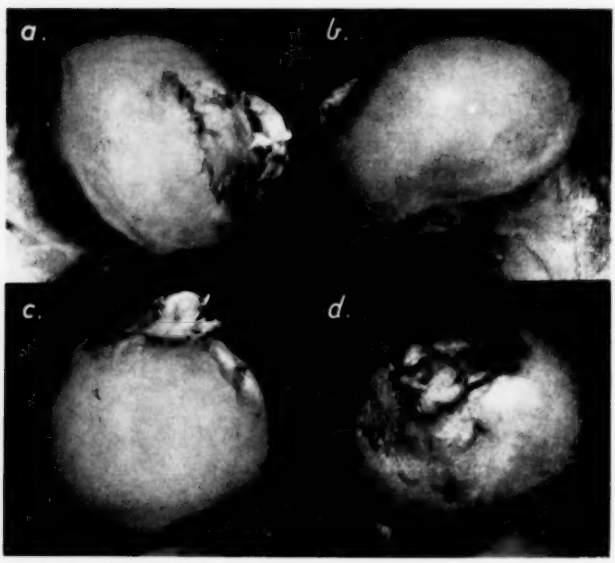

FIG. 9

Examples of the degenerate cartilage visible on femoral heads examined post-mortem. Figure 8—Subject aged eighty-two. Figure 9—Subject aged seventy-nine. In each figure, *a*.—posterior surface, *b*.—anterior surface, *c*.—superior surface, *d*.—medial surface. In both specimens the cartilage degeneration is confined to the non-pressure areas. It is relatively mild in Figure 8 and severe in Figure 9. Note that the cartilage of the principal weight-bearing surface depicted in view *c* is well preserved.

relationship be established between the age of the subject and the severity of the cartilage degeneration.* The comparison of the cartilage lesions of thirty-four femoral heads with their respective radiographs strongly suggested that the more evident the articular degeneration within the non-pressure areas the more clearly visible was the pressure system on radiography. Those femoral heads which had a diffuse infantile type of trabecular architecture showed the least cartilage degeneration and the greatest cartilage preservation.

Comment. Most investigators believe that the articular cartilage is the first tissue to show change in a joint which is becoming osteoarthritic. Nichols and Richardson (1909), Allison and Ghormley (1931), Lang (1934), Bennett *et al.* (1942) and Collins (1949) are among those who have expressed this opinion whose truth has been seen in this present study. We have

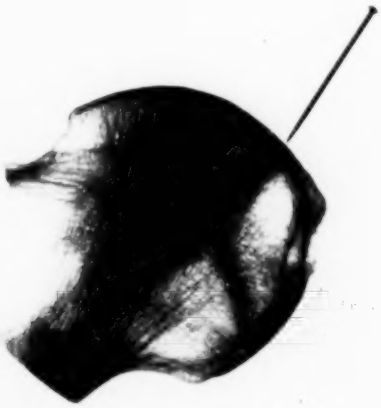

FIG. 10

Radiograph of a coronal section cut from a femoral head. Before radiography a pin was placed at the superior border of the degenerate cartilage on the medial aspect of the head. It will be seen that this pin coincides with the medial border of the pressure system.

not, however, found any reference to the fact that the commonest sites of this change are those parts of the joint exposed but little, if at all, to the stresses and strains of joint function; indeed the opinion which is frequently reiterated in the literature is that "excessive wear and tear" is the causative factor of cartilage degeneration. Our somewhat surprising findings have forced us to consider that if excess of joint pressure is deleterious to hyaline cartilage the lack of pressure is an even more compelling cause of its degeneration.

The necessity for use and compression of cartilage in order to maintain its continued health strongly suggests that mechanical forces are concerned with cartilage nutrition. We have described elsewhere (Trueta and Harrison 1953) a system of vessels found immediately

* Detailed study of the early stages of osteoarthritis of the hip is not possible in material recovered from operation, for patients are not subjected to surgery until the disease is far advanced. For this reason we have investigated the inception of the osteoarthritic process in post-mortem examination of the hips of persons dying from a variety of causes. Such joints exhibited every degree of severity of the disease from the slightly affected to that indistinguishable from the appearance seen at arthroplasty. We believe that the lesions described in this report as constituting the early stage of the disease based upon post-mortem studies are truly the forerunners of advanced osteoarthritis; one can clearly see the evidence of their earlier existence and distribution amidst the bizarre distorted joint wreckage that is removed at operation on living patients.

beneath the calcified zone of the articular cartilage, an arrangement that could be well suited for the supply of nutriments. Study of a series of papers from Swedish workers such as those by Ingelmark and Saaf (1948), Ingelmark (1950), Ekholm (1951) and Ekholm and Norback (1951) shows not only that materials can in fact pass into cartilage from its subchondral surface but that joint function materially increases this passage. This does not in any way decry the nutritive value of synovial fluid. It seems probable to us that the intermittent pumping action of alternate pressure and rest is essential for adequate nourishment of articular cartilage and we have found that Müller had suspected this in 1929. Certainly the weight-bearing areas contain cartilage of greatest thickness and mucopolysaccharide content.

Joint pressure which is excessive either in quantity or duration would prevent the adequate tissue-fluid exchange of the cartilage and thereby be likely to interfere with normal metabolism and promote its degeneration. This concept enables one to understand the

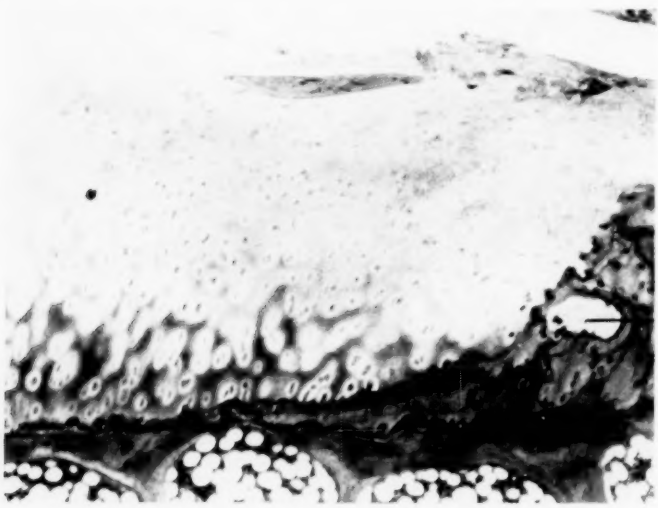

FIG. 11

Photomicrograph showing increase in depth of the calcified cartilage. The section depicts articular cartilage in an early stage of degeneration and as the calcified layer is traced from left (*a*) to right (*a'*) across the field it is seen to increase in depth and spread widely into the previously uncalcified cartilage. At *b*, a blood vessel has advanced deep into the calcified layer. The connection between the vessel and the marrow circulation cannot be seen in this section. (H. and E. × 39.)

mechanism of degeneration of that cartilage in the human hip joint which is excluded from the intermittent compression of movement and weight bearing, and also the experimental observations of Fisher (1929), and of Bennett and Bauer (1937), that degeneration occurred in the cartilage of the trochlear surface of the rabbit's femur after displacement of the patella. Similarly Policard (1936) and Retterer (quoted by Franceschini 1944) found thinning of articular cartilage after inactivity of a joint.

After these considerations of the initial cartilage degeneration we shall follow the subsequent fate of, first, the cartilage of the non-pressure areas and, later, that of the pressure area.

The sequelae of the early cartilage lesion within the non-pressure area. Following the degeneration and reduction in depth of the non-calcified part of the cartilage, the calcified zone increases in thickness and the darker staining bands within it increase also in depth and number (Fig. 11). Calcification thus moves surfacewards into the radial zone of the

FIG. 12

FIG. 13

Vascular invasion of degenerate articular cartilage. Figure 12—At *a*, an artery passes superficially into the thickened calcified zone (H. and E. × 39). Figure 13—Higher magnification of the artery shown in Figure 12 (× 200). (Injection mass barium).

FIG. 14

FIG. 15

Formation of bone and marrow within degenerate articular cartilage. Figure 14—Coronal section of a femoral head. Whereas the articular cartilage of the pressure area is well preserved, that of the medial non-pressure area is degenerate. The trabeculae of the pressure system are clearly visible. (H. and E.) Figure 15—A part of the enclosed area of Figure 14 shown at higher magnification. Bone and marrow have been formed within the degenerate articular cartilage. *a*—subchondral bone plate. *b*—surface covering of fibrocartilage. (H. and E. × 70.)

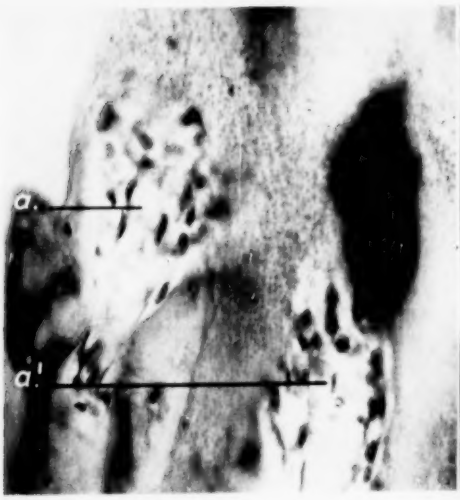

FIG. 16

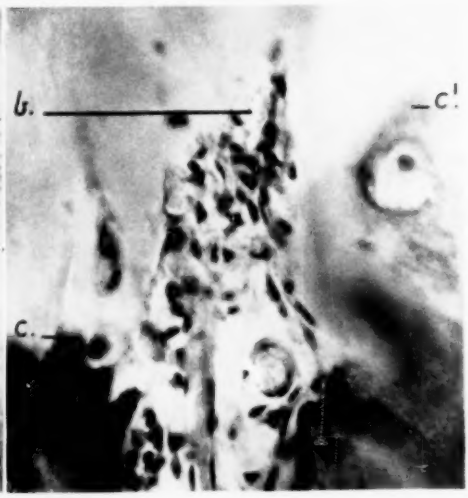

FIG. 17

The relationship between the invading blood vessels and the articular cartilage. Figure 16.—Two separate vascular penetrations, *a*, and *a'*, are shown in which the vessels and their accompanying cells are in contact with an articular cartilage whose punctate basophilia indicates its calcification. Figure 17.—The invading vessel, *b*, has passed superficial to the calcified articular cartilage, *c*, and *c'*, and is in contact with uncalcified hyaline cartilage. (H. and E., ×300.)

non-calcified cartilage. As the process continues the subchondral blood vessels enter the calcified cartilage (Figs. 12 and 13) and progress towards the joint surface, their rate of advance being paralleled by that of the cartilage calcification. It thus comes about that where once there was a normal non-calcified cartilage which became degenerate, there is now a highly vascular marrow, calcified cartilage and bone (Figs. 14 and 15). The vessels spread widely into the cartilage advancing towards and parallel to the joint surface, usually but not always (Figs. 16 and 17) preceded by a vanguard of calcification. A layer of fibrocartilage in varying degrees of degeneration covers the vascular marrow and the newly formed bone; these tissues which have been laid down at the expense of the degenerate articular cartilage constitute the osteophyte. We use the term osteophyte to indicate any new bone and marrow formed within a degenerate articular cartilage and do not restrict it as do other writers to projecting masses of bone and cartilage found at the periphery of the articular surfaces. The evidence for such a definition is presented below.

FIG. 18

The areas of origin of the osteophytes. The two large arrows indicate the usual directions of spread of the peripheral and foveal osteophytes. The smaller arrow represents osteophyte growth within the head.

The topography and vascular anatomy of the osteophyte.—The earliest osteophytes visible are those found at the junction of articular cartilage and synovial membrane. On the femoral head such junction occurs at the margin of the fovea capitis medially and at the periphery of the articular cartilage laterally. The area of origin of these two groups of osteophytes is represented diagrammatically in Figure 18.

It has already been pointed out that the origin and growth of an osteophyte depends upon the proliferation of blood vessels into the degenerate articular cartilage and

in these peripheral osteophytes the vessels come from the adjacent subsynovial tissues. This we term extra-capital vascularisation (Figs. 19 and 20). Other osteophytes invisible to naked eye examination of the external surface of the head are forming elsewhere in the medial non-pressure area and may be seen in slab radiographs and histological preparations (Fig. 21). The vessels in such osteophytes are derived from the subchondral vessels; this we term

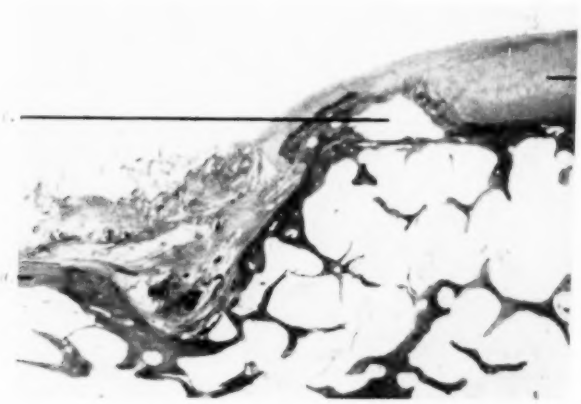

FIG. 19

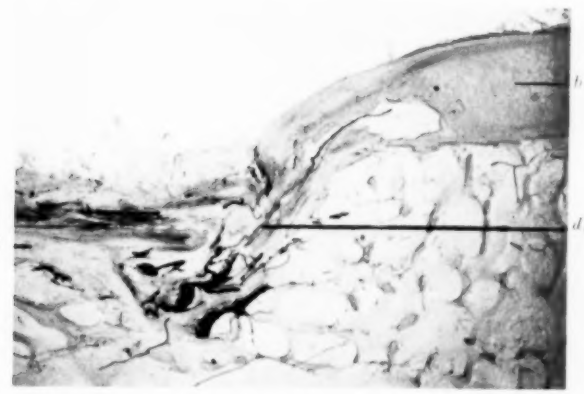

FIG. 20

Extra-capital vascularisation of an osteophyte of the peripheral non-pressure area. Figure 19. Photomicrograph showing the junction of the superior border of the femoral neck, *a*., with the articular cartilage of the femoral head, *b*. *c*. is a marrow space within a small osteophyte formed at the edge of the articular cartilage. (H. and E. × 7.) Figure 20. The same field photographed from the immediately preceding serial section. An artery, *d*., is running in the subsynovial connective tissues to enter the osteophyte. Unstained section 400μ thick, injection mass barium. (× 7).

intra-capital vascularisation (Fig. 22). Initially an osteophyte is often vascularised exclusively from either one of these two sources, depending on its position, but ultimately most receive their blood from both the intra- and extra-capital vessels.

As an osteophyte increases in size its growth is preceded by the intra-cartilaginous spread of the original vascular penetration and by the appearance of new vessels from whichever source did not contribute initially; these groups of vessels and the bone they form gradually

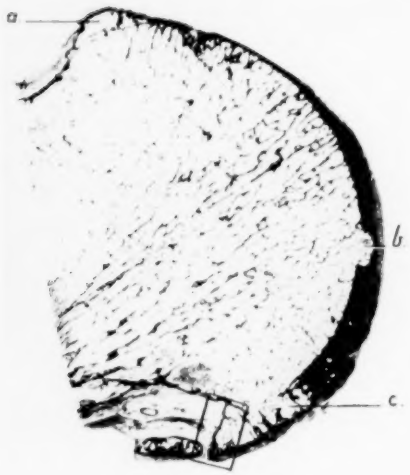

FIG. 21

FIG. 22

Figure 21.—Coronal section of a femoral head. The articular cartilage has disappeared from the pressure area; that of the non-pressure areas shows osteophyte formation at *a*, *b*, and *c*. (H. and E.) Figure 22.—Intra-capital vascularisation. Photomicrograph of the osteophyte *b* in Figure 21. *a* = subchondral bone plate. *b*, *b*[1] = vessels serving the sinusoidal bed of the osteophyte. (Section 400μ thick, unstained preparation. Injection mass barium preceded by Berlin blue. ×9.)

tend to coalesce. It is quite common to find, as depicted in Figure 23, the original articular cartilage and subchondral bone plate of the non-pressure area persisting beneath the osteophyte; extra-capital vessels are then chiefly responsible for the new growth of tissue and arteries can be seen within the osteophyte running parallel and superficial to the old articular cartilage (Fig. 24). Within the osteophyte the pattern of the smallest vessels is frequently sinusoidal; in these instances the marrow of the osteophyte is red (Figs. 25 and 26).

The expansion of the osteophyte in a medial direction is, as everywhere, preceded by the spreading of the blood vessels into the adjacent articular cartilage (Fig. 24). Lateral growth is probably associated with a distinctive vascular arrangement found at the projecting margins of the peripheral osteophytes. Here, a great number of blood vessels are present in the subsynovial tissue which lies between the peripheral osteophyte and the femoral neck and these give rise to

FIG. 23

Coronal section of osteoarthritic femoral head removed at arthroplasty. A large osteophyte, *a*, grows on and over the cartilage of the medial non-pressure area. Part of the original articular cartilage persists beneath the osteophyte. (H. and E.)

a series of parallel straight vessels which course along the deep surface of the osteophyte (Fig. 27). Examination of this surface shows bone lamellae being laid down by intramembranous ossification parallel to these vessels.

FIG. 24

The vascular tree within an osteophyte of the medial non-pressure area. An artery running superficial and parallel to the subchondral bone plate, *a*, distributes branches to the osteophyte which grows not only towards the joint surface but also at its medial extremity, *b*. Intra-capital vascularisation is beginning at *c*. (Spaltebolz preparation, injection mass barium. × 8·5.)

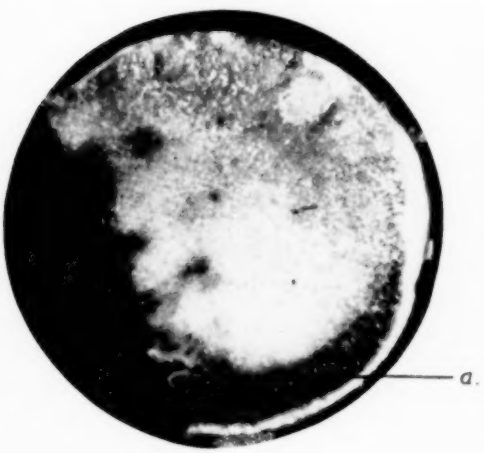

FIG. 25

FIG. 26

A photograph (Fig. 25) and a radiograph (Fig. 26) of a coronal slice from an osteoarthritic femoral head removed at arthroplasty. The osteophyte of the medial non-pressure area, *a*, is seen to contain red marrow.

We must emphasise that without exception the spread of osteophyte formation is limited to those areas within the joint which do not transmit weight; the tendency of osteophytes to grow into the free spaces of the joint outside the weight-bearing areas allows maximum

growth inferiorly (Fig. 28). In advanced osteoarthritis these large inferior osteophytes coalesce with those of the medial non-pressure area and with the ring of osteophytes situated at the margin of the joint cartilage (Fig. 29). As will be seen in this figure, the peripheral circle of osteophytes projecting from the edge of the femoral head forms one wall of a groove or gutter which runs around the neck and is occupied by synovial and subsynovial tissue (Fig. 30).

Comment.—Osteophytes have frequently been considered the most characteristic features of osteoarthritis; indeed the disease has been named hypertrophic arthritis with reference to these structures. There has been considerable speculation about their pathogenesis and significance and the findings of this investigation clash with several ideas that have previously

FIG. 27

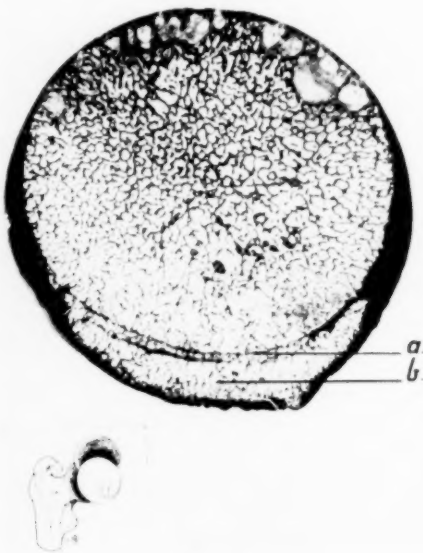

FIG. 28

Figure 27.—The vascular arrangement at the projecting "marginal spur" of an osteophyte. Photomicrograph of the area enclosed by the rectangle in Figure 21 at higher magnification. *a*, inferior border of femoral neck. Numerous vessels run towards the apex of the osteophyte, closely applied to its deep surface, *b*. (Unstained section 400μ thick, cut immediately preceding the one illustrated in Figure 21. Injection mass barium preceded by Berlin blue. ×11.) Figure 28.—A sagittal section of an osteoarthritic femoral head. The original subchondral bone plate is visible at *a*, and this area of the head has now been covered over by the osteophyte, *b*. The small diagram illustrates the plane of section.

been put forward. We see no justification for referring to osteophytes as "marginal" structures; they grow in any area of low joint stress, of which the peripheral border of the articular cartilage is but one. They cannot therefore be considered the resultants of various mechanical stimuli which might operate at the junction of the articular cartilage and synovial membrane (Bennett and Bauer 1937), nor are they in any way secondary to articular cartilage degeneration occurring more centrally (Fisher 1922 and 1929, Bennett *et al.* 1942).

The osteophyte is the result of an attempt to revitalise degenerating cartilage, a degeneration which, as pointed out in the preceding comment, is most commonly due to malnutrition caused by the lack of an adequate and alternating pressure. This inadequacy of pressure is dictated by the joint anatomy and restricted function, and the osteophytes mark the site of a biological response to a tissue sick from under-work. There is a close similarity between the sequence of events responsible for the normal growth of bone and that

which produces the osteophyte. The inception and growth of primary and secondary ossification centres and the ossification at the epiphysial plate resembles osteophyte production in that a penetration of blood vessels into a degenerating and calcified cartilage is followed by the formation of bone. In osteoarthritis, however, the stimulus to this vascular invasion is apparently not a growth hormone but a metabolic disorder taking place in situ.

Pommer, and Lang (1934), understood the significance of the vascular invasion of cartilage in osteoarthritis, but in their theory of the disease they failed to appreciate that it is the lack of pressure on cartilage rather than an excess which most commonly promotes this process and which exclusively allows it to flourish.

FIG. 29

The black areas indicate diagrammatically the distribution of the osteophytes in advanced osteoarthritis; at the bottom right the block of coalesced osteophytes is shown detached from the head. The point of the arrow G lies in the gutter which circles the femoral neck between it and the overhanging marginal portions of the osteophytes.

The sequelae of the early lesion within the pressure area Under the influence of pressure and joint movement the degenerate articular cartilage of this area becomes progressively thinned until only the basal layers of the radial or even the calcified zone may remain. Such changes are responsible for the progressive decrease of joint space seen in the radiographs. This degenerate cartilage also is invaded by the subchondral vessels, but the bone which is produced thereby is sclerotic and this process of osteogenesis tends to be effaced by certain further events which will be described below.

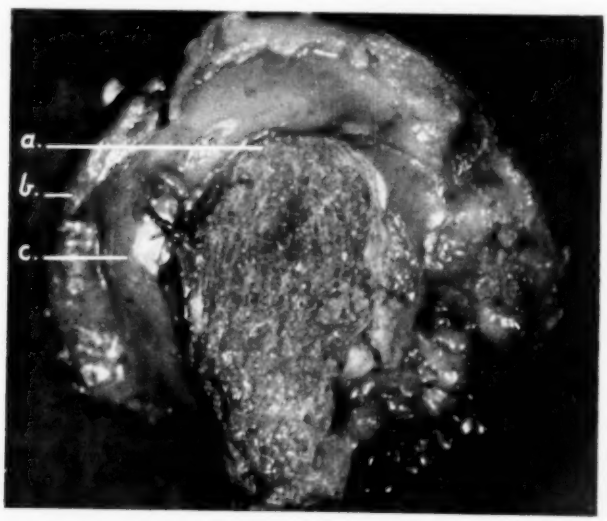

FIG. 30

An osteoarthritic femoral head removed by section through the neck of the femur. The specimen lies upon the fovea capitis and presented to the camera is the cut surface of the neck, *a*, and the projecting tips of the marginal osteophytes, *b*. The synovial membrane, *c*, occupies the interval between these two structures.

The arterial pattern of the osteoarthritic femoral head—The response of the small vessels adjacent to the degenerate articular cartilage with which we have so far been concerned is accompanied by changes in the larger arteries within and around the osteoarthritic femoral head. In advanced osteoarthritis the outstanding feature is the state of hypervascularity which exists when compared with the normal; this occurs with the retention of the overall arterial pattern of the normal state (Figs. 31 and 32). Apart from the normal vascular pathways there is in osteoarthritis a series of vessels entering and leaving the head in the depths of the gutter between the peripheral osteophytic ring and the femoral neck. The vascular foramina

FIG. 31 FIG. 32

Angiograms, in the antero-posterior plane, of the femoral heads of a subject aged seventy-six. The right (Fig. 31) is the site of advanced osteoarthritis. The left (Fig. 32) is in an excellent state of preservation. The arteries within the osteoarthritic head are dilated and increased in number, especially the epiphysial vessels. (Both specimens injected by the same technique. Injection mass barium.)

through which these vessels pass can only be seen when the fibro-fatty synovial tissue which fills the gutter has been removed (Fig. 33). In contrast to this new vascularisation of the head, the medial epiphysial blood flow must often be reduced in importance as the ligamentum teres becomes compressed by the growth of the foveal osteophytes; commonly the ligament is reduced to an attenuated strand.

Comment—Quite a few investigators have considered that a vascular disorder is responsible for the etiology and pathogenesis of osteoarthritis; many have favoured a concept of ischaemia. Wollenberg (1909) put forward this view and Goldhaft *et al.* (1930) reaffirmed it. Bürger and Müller (1921), and Phemister (1940), suggested that primary changes of the subchondral vessels might result in nutritional interference with articular cartilage. Strangeways (1920) and Lacapère and Drieux (1952) considered that such interference might follow a decrease in the calibre of the synovial arteries with a resulting change in the synovial fluid. Pridie (1952) stressed that an original vascular catastrophe within the neck of the femur is responsible for osteoarthritic changes within the head. Therapeutic implications of the supposed ischaemic state have been made, among others, by Venable and Stuck (1946), Cheynel (1947) and Camera (1952).

We have been fortunate to have at our disposal techniques which have revealed the

vascular tree within the bone and soft tissues of the joint at the various stages of the disease. These have shown a state not of ischaemia but of vascular profusion and dilation. This is to be seen at its greatest in the advanced stages of osteoarthritis, but angiographic studies earlier in the disease have shown that this in no way represents a reaction to an earlier ischaemia. The osteoarthritic process from its inception entails the appearance and growth of new blood vessels, and as it evolves so does the vascular tree in and around the bone. We are now investigating whether the pain so characteristic of osteoarthritis is dependent upon this particular feature of the disease.

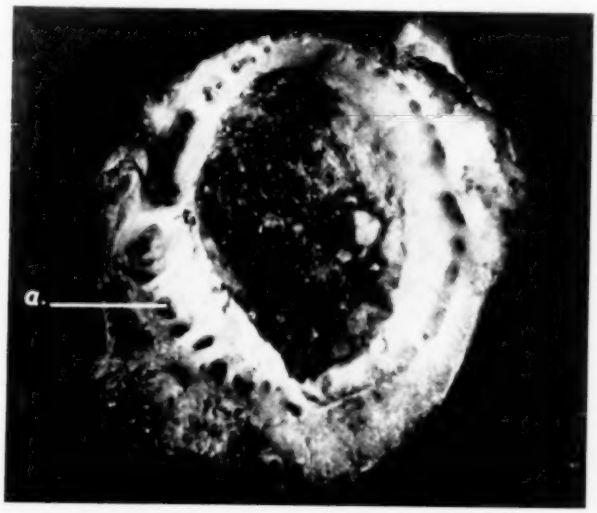

FIG. 33

The same specimen as depicted in Figure 30 after removal of the synovial membrane and subsynovial connective tissue. A series of foramina are now visible in the depths of the gutter, *a.*, between the femoral neck and the marginal osteophytes.

THE DESTRUCTIVE PHASE

The osteoarthritic process up to the stage we have just described has been in its productive phase, wherein a state of hypervascularity has been produced in response to a stimulus provided by the degenerating articular cartilage. This response has been accompanied by the formation of osteophytes which, from a modest beginning in the non-pressure areas, later reach their greatest development after certain occurrences within the pressure segment have further decreased the congruency of the joint. These take place in the second or destructive phase of the disease.

The flattening of the femoral head. As osteoarthritis develops in the hip there is a progressive increase in the load that a part of the joint is called upon to bear. This is because muscle spasm, capsular thickening and anatomical incongruity steadily decrease the range of movement of the joint and therefore only a restricted segment of the pressure area is used for weight bearing. The bony architecture of the head, rarefied and weakened by the hyperaemia already described, receives this increased load whose crushing effect is heightened by the progressive loss of resilient articular cartilage from the pressure area. As joint movements are lost and the pressure area becomes more circumscribed the cancellous bone of the head evolves further away from the pattern of youth and the pressure system of trabeculae becomes denser, appearing radiographically more distinct, partly because of the rarefaction of the surrounding bone. The result of this increase in the load and weakening

FIG. 34

FIG. 35

Flattening of the femoral head. The two radiographs show the progress of osteoarthritis in a hip joint during eighteen months. In the later radiograph (Fig. 35) the flattening of the femoral head is associated with further loss of the articular cartilage from the superior part of the joint and the appearance of cysts in the neighbouring areas of the ilium and femoral head.

of the support is that the head starts to decrease in height from successive trabecular fractures. At first only the superficial trabeculae break down but these are followed by fractures of deeper strata. In this way the top of the femoral head becomes flattened (Figs. 34 and 35); the bone of the collapsed segment increases its density in the radiographs.

Characteristics of the pressure area in advanced osteoarthritis.—The combination of excessive pressure and friction which operates in the pressure area destroys the full thickness

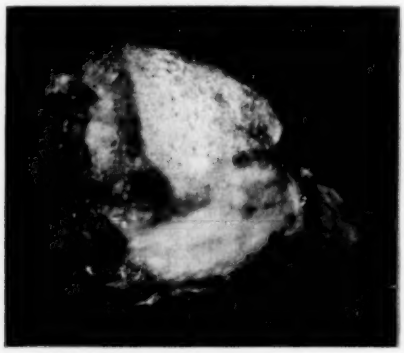

FIG. 36

Part of a femoral head removed at arthroplasty. Bone is exposed on the superior surface of the head, the cartilage of the pressure area having been lost. The articular cartilage that is visible is for the most part the cartilaginous covering of the osteophyte and not the original surface of the head which has been covered over and now lies at a deeper level. See Figures 23 and 28.

of the non-calcified cartilage and denudes the upper surface of the femoral head (Fig. 36). The appearance of this area is never uniform because four different tissues may be found there: these are the calcified zone of the cartilage (Fig. 37), necrotic bone lamellae (Fig. 38), living lamellae, and aggregations of newly formed cartilage of varying degrees of cellularity.

It is the first two tissues which endow the surface with its shiny smooth "eburnated" appearance; the newly formed cartilage is either set slightly below the surface in small "pits" or protects superficially as sproutings (Fig. 39).

The tissues of the pressure segment of the head of femur after flattening has occurred. The marrow, bone trabeculae and the vascular pattern of this area all have distinctive features and, as will be made apparent in the discussion, these may possibly have a common origin. The several appearances will now be detailed.

FIG. 37

Photomicrograph of part of the eburnated surface of the pressure area from a severely osteoarthritic femoral head. *a*.—calcified cartilage. *b*.—dilated venule within the fibrous marrow. The greater part of the thickened bone appears healthy; in the immediate subchondral area there are some acellular lamellae. (H. and E. ×54.)

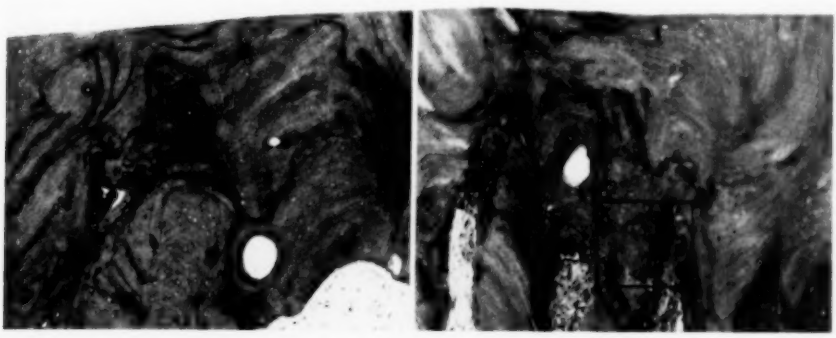

FIG. 38

Photomicrographs of two parts of the pressure area of a severely osteoarthritic femoral head. In both fields the articular surface is constituted by sclerotic and necrotic bone lamellae which extend deeply and irregularly into the head. (H. and E. ×37.)

The marrow is completely different from either haemopoietic or fatty marrow and its general appearance is best described as fibrous with variations depending upon degrees of cellularity and types of fibre component. A further constant feature is the presence of intercellular fluid highly suggestive of a state of oedema. The bone trabeculae are thicker than normal and more sinuous in shape and consist of healthy lamellae sometimes covering dead bone; they constitute the sclerotic bone whose density is so apparent in clinical and slab radiographs. The vascular pattern of the region, in addition to the arterial hyperaemia evidenced in Figure 31, is dominated by a state of venous engorgement which is represented

among the small vessels by large numbers of dilated veins and sinusoids (Figs. 40 and 41). These vessels have the same general configuration as normal sinusoids (Trueta and Harrison 1953) but differ in the increased calibre of the individual vessels and the size of the meshwork which they form by their anastomoses (Figs. 42 and 43).

The three tissue appearances just described are not spread diffusely throughout the head but are found restricted to the upper part of the pressure segment. Study of a large number of preparations has impressed us with the frequency with which the sclerotic bone and fibrous marrow has the shape of an inverted cone whose apex lies inside the head and whose base is formed by a portion of the naked eburnated surface of the pressure area (Figs. 44 to 46).

Two further and most important features of this part of the osteoarthritic head must now be mentioned: the cysts of osteoarthritis and the presence of necrotic bone and marrow.

FIG. 39

A photomicrograph of part of the pressure area illustrating how the bone marrow differentiates into fibrocartilage. This newly formed cartilage projects superficially beyond the bone margin into the joint cavity. (H. and E. ×45.)

The cysts of osteoarthritis—We shall apply the term cyst to those transradiant areas which may often be seen in clinical radiographs of osteoarthritic hips. Their appraisal is more accurate if the osteoarthritic head is sectioned and the several slices radiographed; additional information is obtained if the plane of section is varied in different specimens. By this method of investigation combined with microscopic study the following conclusions have been drawn. Every osteoarthritic head in our series which had been removed at operation contained cysts. The cysts were found restricted to the upper part of the pressure segment and lay within the conic areas of dense bone deep to the eburnated articular surface. The number of cysts present in any one specimen was variable; it is usual to find several; the solitary cyst is less common. The cysts are frequently cup-shaped or pyriform and whereas the former obviously communicate with the joint cavity the " stoma " of the latter (Fig. 47) may be missed by the plane of section used in preparing the material for slab radiography or microscopy. Under such circumstances the structure might seem to be a discrete spherical lesion within the bone, separate from the joint cavity (Figs. 26, 28 and 51); but in many such cases we have been able to demonstrate the actual communication by varying the plane of section.

We desire to relate the topographic and histological features of the cysts to the tissue appearances already described as obtaining in this zone. Thus the morphology of the fibrous

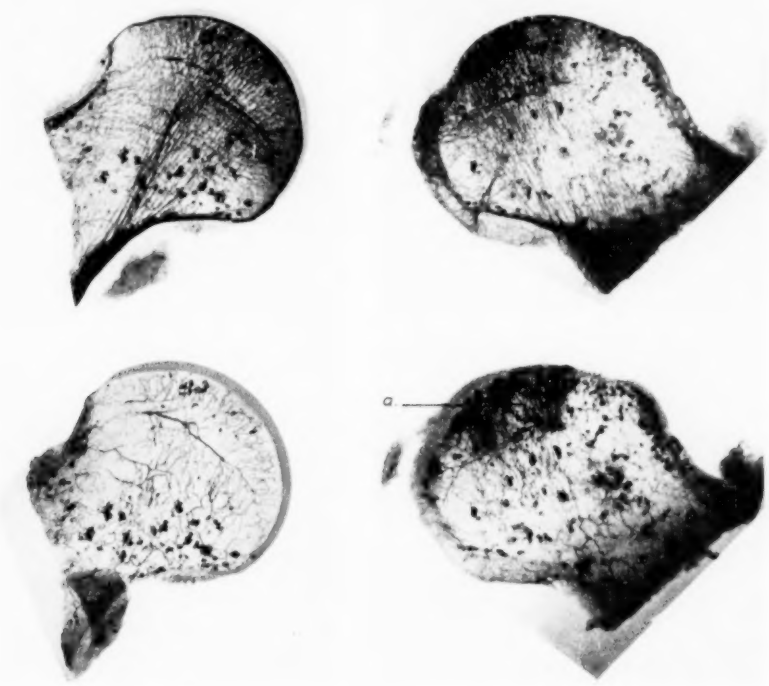

FIG. 40

FIG. 41

Venous engorgement within the pressure segment of the osteoarthritic femoral head. Slab radiographs (upper photographs) and angiograms (lower photographs) from the right and left femoral heads of a subject aged seventy-seven. The right femoral head (Fig. 40) was well preserved. The left (Fig. 41) was the site of advanced osteoarthritis. The multiple punctate opacities within both angiograms are collections of sinusoids; the conical area, *a*, in the osteoarthritic specimen is an accumulation of dilated sinusoids and veins. (Both specimens injected by the same technique. Injection mass barium preceded by Berlin blue.)

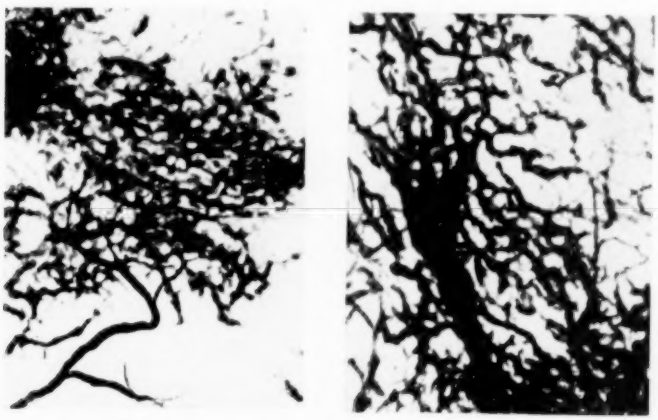

FIG. 42

FIG. 43

Photomicrographs showing normal sinusoids (Fig. 42) from the femoral neck compared with congested sinusoids from the pressure segment of the same osteoarthritic femoral head (Fig. 43). (Both photographs made from an unstained section, 400μ thick. ×20. Injection mass barium preceded by Berlin blue.)

FIG. 44

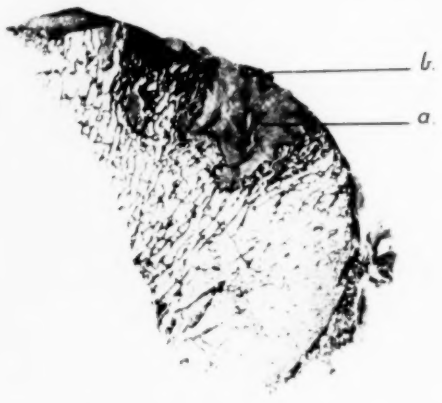

FIG. 45

Sclerotic bone in advanced osteoarthritis. A slab radiograph (Fig. 44), and a photomicrograph (Fig. 45) of a coronal slice taken from a femoral head removed at arthroplasty. The outline of the sclerotic bone which occupies the upper part of the pressure segment of this femoral head is triangular. Within this zone, in Figure 44, there is a transradiant area which microscopy shows to be filled by dense fibrous and fibrocartilaginous tissue (*a*, Fig. 45). The fragment of bone, *b*, surmounting this area and projecting into the joint was found to be completely necrotic.

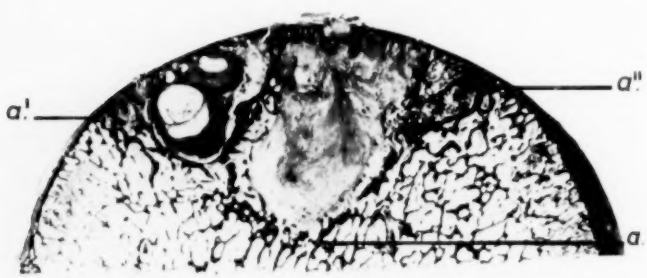

FIG. 46

The upper half of a sagittal section of a severely osteoarthritic femoral head; the small diagram shows the plane of section. A triangular shaped complex of sclerotic bone and fibrous marrow is present within the head. One corner of the triangle lies deeply, *a*.; the other two (a^{I}, a^{II}) lie at the articular surface. Two large areas of fibrous tissue showing varying degrees of cavitation lie within the triangle; such fibrous tissue is transradiant and appears as a cyst in radiographs.

tissue within the cysts is as varied as that elsewhere in the pressure segment and may be loose and myxoid, dense (Figs. 48 to 50) and on occasions fibrocartilaginous. The former varieties are associated with intercellular fluid, often under tension, and the latter with anatomical conditions exposing the tissue to the stimuli of joint movement (Figs. 44 and 45).

The vascular pattern of the cysts is distinctive. Dilated vessels of sinusoidal pattern occupy the conical areas which we have described within the pressure segment. As the cysts are approached the degree of dilation increases, reaching its greatest at their edge where a layer of large thin-walled anastomosing venules lines the bony wall of the cyst (Figs. 51 and 52); a number of slender arterioles can be traced into continuity with these, the transition between the two often being somewhat abrupt. The fibrous tissue of the cyst contains a few of both these types of vessels but the paucity therein is most striking when compared with the profusion that exists around its walls and in the surrounding tissue.

The bony wall of the cyst is formed by thickened trabeculae. Osteogenesis is frequently evident there and tends to be most marked around the "neck" of the cyst whereas it is usually absent in the "fundus."

Necrotic bone and marrow Reference has already been made to the necrotic bone which is to be found on the surface of the pressure area. Such tissue is often in unbroken continuity with zones of necrosis extending for a considerable depth into the upper part of the pressure segment. It is common to find necrotic tissue scattered irregularly throughout this part of the head after flattening has occurred, and, judging from histological appearances, the necrotic process is an aseptic one. The necrotic bone and marrow may remain but little changed, they may be ground into bone "sand," or they may be the site of osteoclastic removal and osteoblastic replacement (Fig. 53). The commonest situation for necrotic bone is within and between the cysts that have just been described. In the present investigation the almost invariable finding of necrotic bone on the surface of the pressure area in advanced osteoarthritic femoral heads has led us to believe that at this advanced stage of the disease ischaemic changes are a usual occurrence.

Comment—The osteoarthritic head during the first or hyperaemic phase has been productive of new joint tissue but in its second or destructive phase the joint tends to disintegrate. What has been responsible for these changes is, we believe, the transmission of an excessive amount of pressure through an excessively limited area of the head for an excessively long time. This severe compression falls upon a head whose structure has been weakened by hyperaemia and from which has been removed the normal resilient and protective covering of articular cartilage. The consequence of these circumstances is the collapse of the head and in its turn this produces further important changes in internal structure.

That the zones of necrotic bone exposed on the surface of the pressure area must be attributed to infarction consequent to collapse is shown by the co-existence there of other zones of living trabeculae; if attrition were the causative factor the surface layers would be uniformly dead. Moreover, the dead lamellae often extend in unbroken continuity into the head to strata which would be unaffected by the polishing action of joint movement. The presence of calcified cartilage upon the surface shows that the flattening of the head is not due to a wearing away but is in fact an impression.

To judge by the devitalised remnants found inside and on the surface of the conical areas of the pressure segment, it is very probable that a series of infarctions has occurred there. The necrotic remnants alternate with vital tissue and with a very marked hypervascularisation which is to be found within the same area of collapse; it appears likely that the layers of new bone which lead to the sclerotic aspect of this part of the head have been laid down in response to scattered necrosis. We have seen that the cysts are aggregations of fibrous tissue, and the process of new bone formation is held at bay in their walls. A possible cause of this arrest of revitalisation is as follows. The cysts lying deep to the eburnated bone and unprotected by cartilage are within the area of transmission of greatest pressure, and,

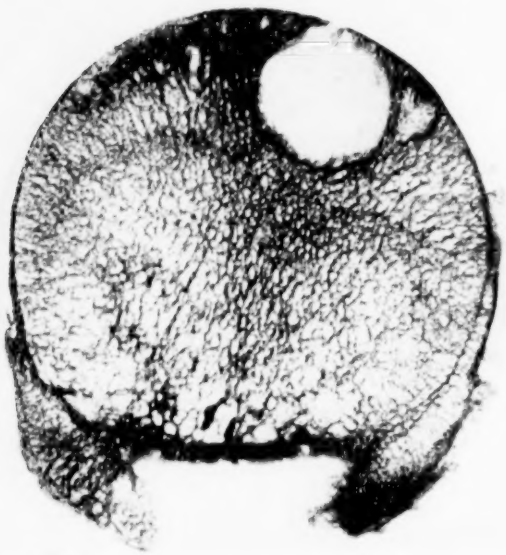

FIG. 47

Slab radiograph showing a large cyst beneath the pressure area of an osteoarthritic femoral head. The cyst is pyriform and communicates with the joint cavity by a small stoma. The plane of section, sagittal, is indicated in the small diagram.

FIG. 48

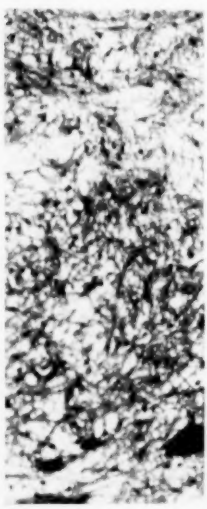

FIG. 49

FIG. 50

The contents of the cyst. The photomicrographs show three different types of tissue from a cyst within an osteoarthritic femoral head. In Figure 48 there are abundant connective tissue fibres. In Figure 49 the framework is made looser by the presence of intercellular fluid, which in Figure 50 has accumulated and formed small cavities. (H. and E. × 100.)

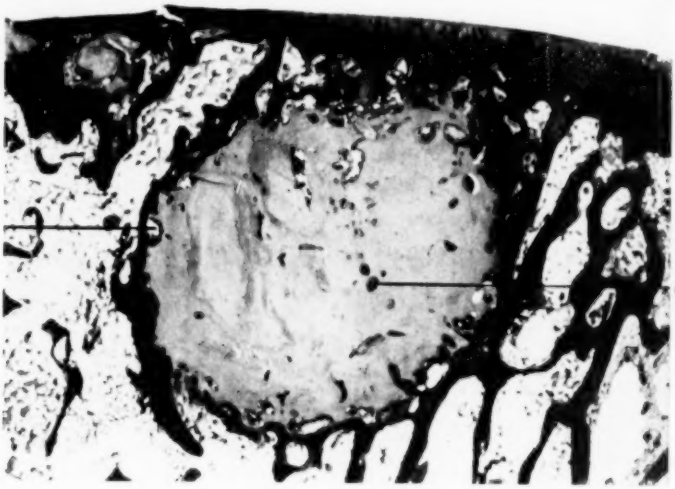

FIG. 51

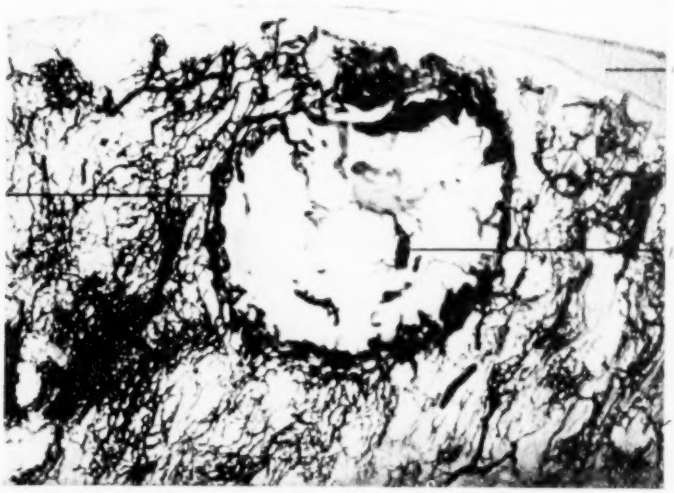

FIG. 52

The vascular pattern of the cyst. Photomicrographs showing a cyst underlying the pressure area of an osteoarthritic femoral head. *a*.—thinned articular cartilage. *b*.—dilated sinusoids and veins lining the cyst wall and (*b.1*) traversing the contained fibrous marrow. (Figure 51—H. and E. Section 15μ thick. ×10. Figure 52—Unstained preparation 400μ thick. ×10. Injection mass barium, preceded by Berlin blue. The different size of the cyst in the two sections is due to its changing appearance on section as the block is traversed.)

because of their communication with the joint cavity, a pressure disturbance will probably enter this area of the head at every step and movement; this may be the factor defeating vascular penetration. That the cysts within the femoral head and the acetabulum can heal if the mechanical forces are redistributed is sometimes evidenced in radiographs showing the progress of osteoarthritic hips after a Girdlestone pseudarthrosis (Figs. 54 and 55), a McMurray osteotomy or an arthrodesis.

Extrusion of the femoral head—The flattened surface of the upper segment of the head of the femur as much as its smoothness favours the displacement of the head laterally, and this increases the width of the joint space infero-medially. The consequent lack of contact acts as a further stimulus to the production of new osteophytes in the non-pressure area of

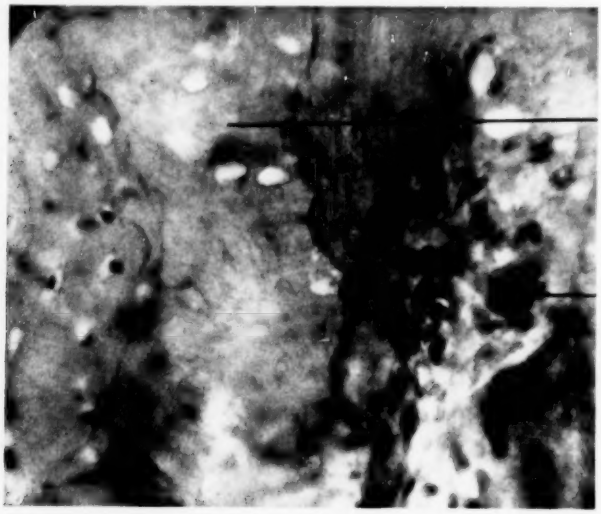

FIG. 53

The enclosed area of Figure 38 seen at higher magnification. *a*—an osteoclast lies in a marrow space next to the necrotic bone, *b*. (H. and E. d = 300.)

FIG. 54

FIG. 55

Osteoarthritic hip (Fig. 54) treated by excision of the femoral head and neck (Fig. 55). Note that the large cyst present in the ilium before operation is subsequently replaced by bone.

the head. From the point of view of the joint stresses the outward displacement of the head further accelerates the process of disintegration. At this stage the restricted pressure zone of the head and its acetabular counterpart are situated marginally, as in congenital subluxation of the hip, but the two contact areas are flat. Under these circumstances the load is distributed

over a further reduced area, and as joint movement becomes increasingly lost the load is carried by the same trabeculae for ever-increasing periods of time. The crushing effect of this overload is felt by even deeper bone trabeculae, with consequent extension of the events and tissue changes already referred to (Fig. 56).

* * * * * * *

There is a reconstructive or healing process present within the osteoarthritic femoral head. We have already referred to osteoclastic removal of necrotic bone and to osteogenic activities within the pressure segment, and at the many places where the fibrous marrow comes to the surface at the pressure area it differentiates into a fibrocartilage which is usually degenerate but at times is almost hyaline in nature. Most commonly these sproutings of cartilage remain discrete (Fig. 39), but, especially in patients whose hip joints have been placed at rest or when mechanical conditions have been changed, these cartilaginous outgrowths become confluent and may resurface the previously naked and eburnated bone. In such specimens the pressure segment usually contains only a few small cysts and little evidence of marrow oedema, fibrosis and bone sclerosis.

FIG. 56

The diagram shows the superimposed outlines, traced from a radiograph, of the upper ends of both femora of the same patient. One hip joint was normal (continuous line), the other was the site of advanced osteoarthritis (interrupted line). The change in the shape of the osteoarthritic bone is due to a combination of irregular flattening of the upper part of the femoral head and the formation of new tissue, the osteophyte, infero-medially.

SUMMARY

Osteoarthritis, as seen in the hip, is a disease which eventually embraces all the tissues of the joint but begins as a reaction of the juxta-chondral blood vessels to a degeneration of the articular cartilage; this reaction results in a hyperaemia of the bone. To our surprise we found that daily use preserves rather than "wears out" articular cartilage; indeed inadequate use is the commonest cause of cartilage degeneration and ensuing vascular invasion. To this factor are added the effects of excessive pressure in the many patients who require surgical treatment for advanced osteoarthritis of a hip the seat of some anatomical incongruity. This etiology based on cartilage suffering does not exclude, but indeed explains, the osteoarthritis implanted on joints of a normal shape which have been previously affected by acute or chronic inflammation or by hormonal dysfunction, such as acromegalic osteoarthritis. The stimulus to vessel growth and invasion is the same in all these cases—namely cartilage damage. Once the vessels have entered the cartilage the bone and marrow of the osteophyte are inevitably laid down. What is so damaging in osteoarthritis seems to be not the degeneration of the cartilage but the vigorous and persistent attempt at repair, an attempt which aggravates the already disordered function of the joint not only by osteophyte formation but by the hypervascularity which weakens the structure of the bone beyond the point where it can carry its increased load. The collapse that follows provokes further reparative efforts with the same deplorable results. The osteoarthritic process thus appears to be an attempt to transform a decaying joint into a youthful one and for this, as in the miraculous rejuvenation depicted in Goethe's *Faust*, a high price must ultimately be paid.

We would like to express our thanks to those who have helped us in this investigation. Dr G. M. Ardran, of the Nuffield Institute for Medical Research, arranged all the radiographic facilities needed for our work and Mr M. Tuckey, working in that department, has taken many of the radiographs. Dr A. H. T. Robb-Smith, Director of Pathology, Radcliffe Infirmary, Oxford, and Dr W. Cosin, Director of Cowley Road Hospital, Oxford, have extended to us the post-mortem facilities of their departments. Mr R. Hill, laboratory technician of this Centre has rendered most valuable assistance in every technical process that we have used and Miss M. McLarty has been most kind in making diagrams and drawings for us. We are grateful to the staff of the Photography Department for the reproductions of radiographs and specimens.

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THE ROLE OF CAPSULAR CHANGES IN OSTEOARTHRITIS OF THE HIP JOINT

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Osteoarthritis is characterised by degenerative changes in the articular cartilage and the bones of the affected joints. These abnormalities are apparent in radiographs and museum specimens. The surgeon who operates upon these joints is, in addition, aware of the striking changes that occur in the capsular and synovial tissues in advanced cases. In this paper I will describe these soft-tissue changes, and then discuss their etiology and their influence upon the clinical manifestations and course of osteoarthritis of the hip. The hip has been chosen because osteoarthritis in this joint frequently demands operation employing exposures that allow inspection and biopsy of any part of the joint.

MATERIAL

The following observations are based upon an operative and histological study of twenty-five osteoarthritic hips subjected to arthroplasty or arthrodesis. In no case did infective, rheumatoid or ischaemic factors determine the onset or complicate the condition. The youngest patient was aged forty-nine and the oldest seventy-three.

The structure and functional anatomy of the normal hip joint were studied by dissection and microscopic examination in seven fresh cadavers, from subjects ranging in age from birth to sixty-five.

THE NATURE AND CAUSE OF THE PATHOLOGICAL CHANGES IN THE SYNOVIAL MEMBRANE AND CAPSULE

The entire synovial membrane of an osteoarthritic hip is congested and unduly villous for the patient's age, especially in certain areas. The lowest part of the joint is most involved, the villi being large and grouped in bunches upon a thickened base. Where the articular cartilage has suffered most a ring of hyperplastic villi may also encircle the head. The villi in the more congested areas are frequently engorged and appear blue, whereas in other, less vascular, areas they may be discrete, firm and white. Intra-articular adhesions are often conspicuous but may easily be overlooked if the external layer of the joint capsule is forcibly separated by a bone lever from the synovial layer investing the femoral neck before the areas of the capsular reflection are inspected, for it is within these synovial pockets that they occur most often, and also between the margin of the head and the surrounding lining of the articular capsule. In patients in whom movement is almost lost, and in whom deformity rather than pain predominates, these adhesions may fill the joint to such an extent that some difficulty may be encountered in defining its cavity, the capsule surrounding the neck like a tight collar. More typically, however, the capsule is thickened and shortened and lacks its normal pliability. Sometimes fibrosis spreads to the adjacent muscles, especially the short rotators, so that these adhere to the outer surface of the capsule and can be reflected only by sharp dissection. Calcification is occasionally present, more particularly on the upper surface of the capsule.

Histological examination of congested areas of synovial tissue, selected at operation, discloses hyperplasia with formation of villi and multiplication of surface cells. The presence

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FIG. 1

Osteoarthritic hip. Synovial membrane and capsule from inferior part of joint. Note the diffuse fibrosis which obscures the junction between synovial membrane and capsule (× 64).

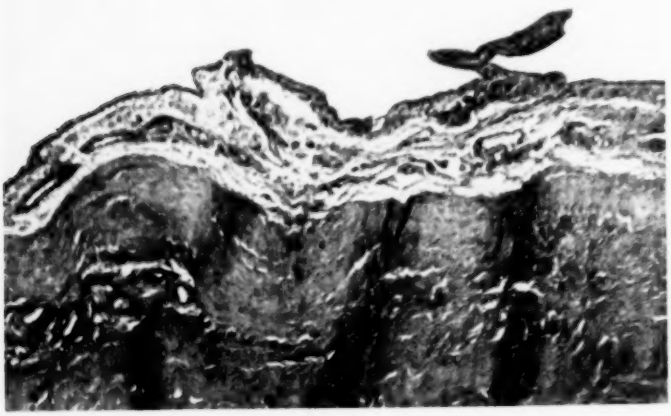

FIG. 2

Contracted capsule. Synovial membrane and capsule from behind elbow joint. The elbow was fixed in extension after a brachial plexus injury nine months before. It could not be flexed until the capsule was divided. The histological appearance is normal (× 64).

of haemosiderin in some specimens, below the surface cells of the villi and in collections in the subsynovial tissue, suggests that haemorrhage may occur into the joint cavity. Perivascular lymphoid aggregations are commonly present and should not be regarded as a rheumatoid manifestation. Metaplasia leading to the formation of cartilage or bone was seen in only two of the twenty-five cases. The pale pedunculated villi, so frequently seen at operation and superficially resembling cartilage, were found to consist merely of connective tissue. less vascular and more fibrotic than usual, and covered by a single layer of synovial cells.

A further striking abnormality is a progressive fibrosis of both the synovial membrane and the capsule. In advanced cases the joint lining becomes almost completely replaced by this scar tissue. Figure 1 illustrates an example of advanced fibrosis which has obliterated the normally conspicuous boundary between subsynovial tissue and joint capsule shown in Figure 2.

In addition the synovial membrane contains debris which appears to be related to the destruction of the cartilage and bone of the degenerated articular surfaces. This extraneous material is found either on the surface or just beneath the lining cells. Histologically it resembles bone or cartilage. The cartilaginous fragments, however, do not show the staining reactions of normal cartilage but those of the degenerated cartilage of the joint surface from which they have presumably been separated. Figure 3 illustrates the articular cartilage from a case of moderately advanced osteoarthritis. The projections of degenerate cartilage have but a tenuous connection with the deeper layers and are obviously liable to become dislodged. Later the bone becomes vulnerable to the same process of attrition.

Once free in the joint cavity these fragments must either persist as loose bodies or adhere to the synovial membrane, for the synovial fluid cannot dissolve them. Experimental studies of other particles introduced into a joint show that they are engulfed by the synovial membrane and are dealt with subsequently in a manner dependent upon their size and nature. Particles larger than 0·1μ cannot be carried away unchanged from the membrane (Adkins and Davies 1940); they either remain permanently, if non-digestible, or they are removed by phagocytosis. The particles of cartilage and bone are too large to be carried away unchanged from beneath the synovial lining but they may undergo digestion in situ (Figs. 4 to 8).

In sections stained by haematoxylin and eosin, the cartilage fragments differ from normal articular cartilage in that there is no sign of the familiar blue metachromatic reaction and the chondrocytes are scanty and atypical. To recognise the relationship it must be realised that these are fragments of degenerated cartilage whose structure and staining reactions are abnormal even before they are dislodged, and which undergo still further changes during their subsequent digestion by the synovial membrane.

The main features can, however, be seen in these preparations. The fragments of cartilage lie on or beneath the surface layer and do not appear to pass deeper during their absorption. They have an eosinophilic reaction which becomes less intense as disintegration proceeds and which is accompanied by an increase in the visible fibrillar network (Fig. 4). Atypical cartilage cells or their remains may sometimes be seen in the larger and less disorganised specimens (Fig. 5). Giant cells are occasionally found nearby. The fragments are clearly demarcated from the surrounding synovial tissue (Fig. 6). Their partial dislocation from their enclosing cells during the process of histological preparation often emphasises this point (Fig. 4). Typically, however, they are small and lie with their long axis parallel to the synovial surface where they can be readily overlooked (Fig. 7).

The cartilaginous nature of some of these fragments is indicated by the slight degree of metachromasia that can be demonstrated by means of the Eosin Azur technique and by a positive periodic acid Schiff reaction. The staining reaction of the cartilaginous debris resembles that of degenerate cartilage from the articular surfaces of osteoarthritic joints rather than that of normal articular cartilage. The fragments show the same reactions with collagen stains as does degenerate articular cartilage in osteoarthritis. Special stains for fibrin prevent confusion between the fragments and the masses of fibrin frequently seen in osteoarthritic joints. Furthermore, examination of the fibrillar structure of these particles by the polarisation method of Price (1952) shows the collagen fibrils to be arranged in a manner similar to that seen in degenerate articular cartilage.

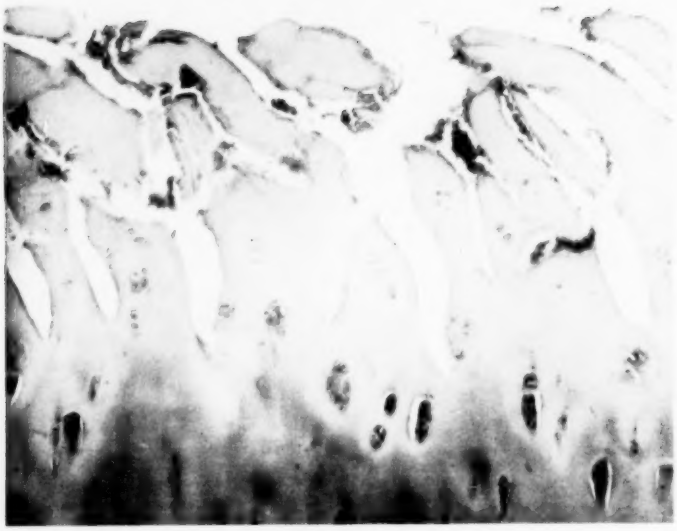

FIG. 3

Articular cartilage from osteoarthritic hip. Note the fragmentation and loss of metachromatic staining in the superficial part of the articular cartilage (×100).

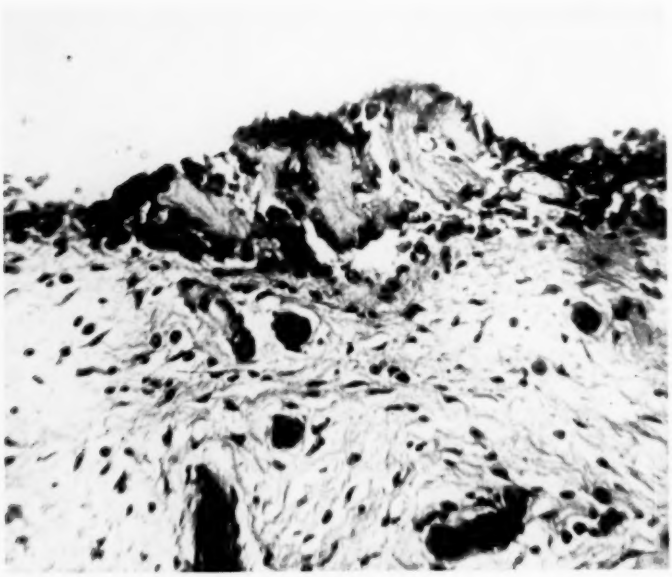

FIG. 4

Osteoarthritic hip. A group of cartilage fragments lying beneath the synovial surface. Note their fibrillar appearance and the partial dislocation which has occurred during preparation (×280).

FIG. 5

Osteoarthritic hip. An exceptionally large fragment of cartilage lying below the synovial surface. The remains of cartilage cell nuclei can be seen (×85).

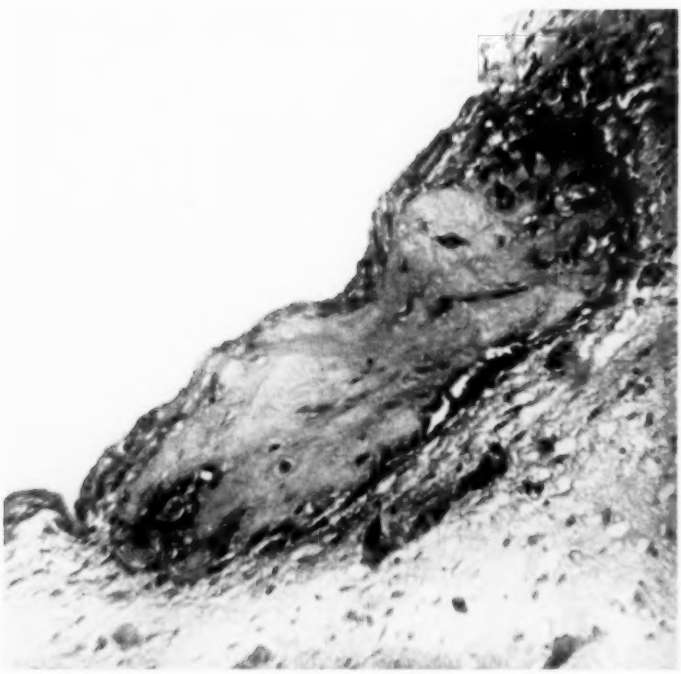

FIG. 6

Osteoarthritic hip. Large cartilage fragment with small bone spicule lying superficial to one edge (×230).

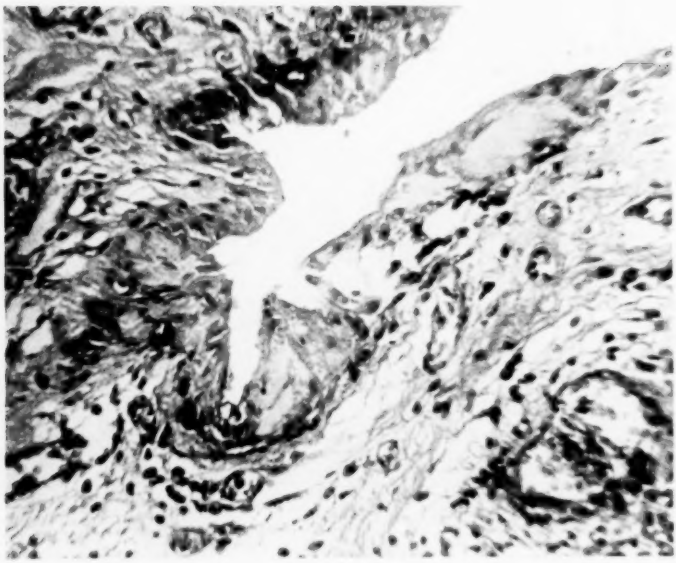

FIG. 7

Osteoarthritic hip. This field shows the typical histological appearance of the cartilage fragments. The space between the main fragments probably contained a fragment which was dislodged during preparation (× 280).

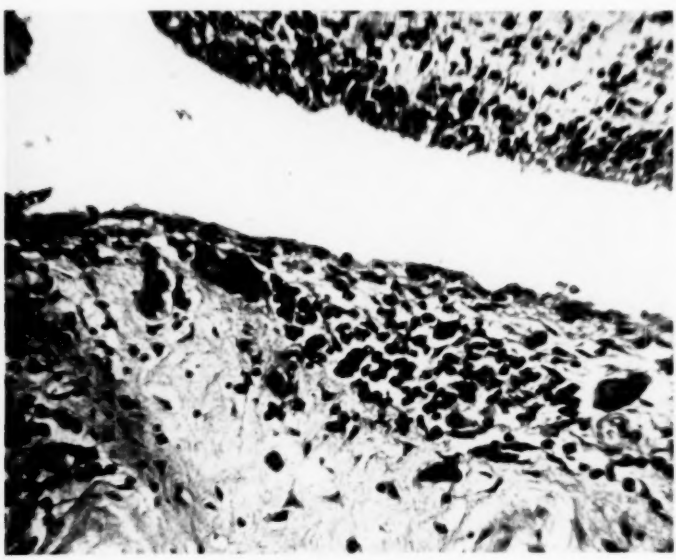

FIG. 8

Osteoarthritic hip. Two bone fragments lie a short distance below the synovial surface. One of them contains a lacuna (× 350).

Bony fragments are more easily recognised as such. They are usually smaller than the cartilaginous fragments and lie at a short distance from the surface (Fig. 8). Unless decalcified they appear in sections as dark brown objects exhibiting optical activity when viewed with polarised light. They become black when stained by the Von Kossa method for the demonstration of bone salts.

I believe that the evidence that has been presented allows us to assume, with some confidence, that these fragments are composed of abnormal articular cartilage and bone. It has been assumed that the source of this debris is the articulating surfaces, whereas it might

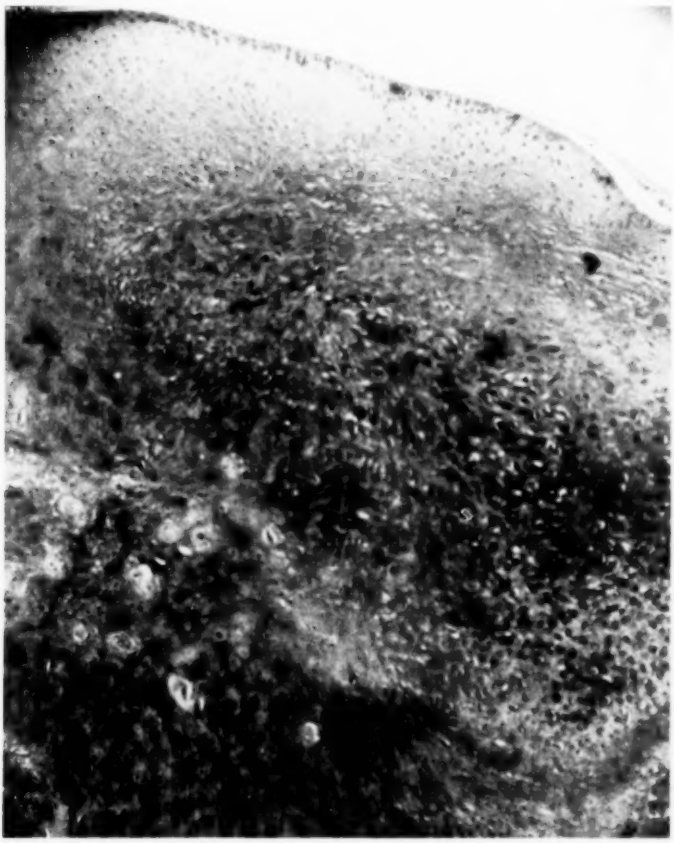

FIG. 9

Synovial membrane in Charcot's osteoarthropathy. There is diffuse metaplasia of the synovial connective tissue with formation of cartilage and calcified cartilage within the deeper layers of the synovial membrane (× 75).

be suggested that it arises within the synovial membrane by metaplasia, a feature of osteoarthritis which has been frequently described. But metaplastic cartilage and bone formations differ in almost every respect from the appearance of the debris that I have described, for metaplasia is a vital process in which the connective tissue of the centre of the villus merges imperceptibly with an area of either metachromatic fibrocartilage, calcified cartilage or bone (Fig. 9), whereas the debris occurs just below the surface, is often clearly demarcated from the surrounding tissue and responds poorly to metachromatic stains (Table I). This distinction was emphasised by Horwitz (1948), who described similar bone

and cartilage fragments in the soft tissues of neuropathic knee joints in addition to areas of metaplasia. He pointed out that these fragments also occurred in two out of a control group of twelve osteoarthritic joints. We have had the opportunity to study one syphilitic neuropathy of the hip joint in which only minor bone changes had occurred. In addition to the marked amount of joint debris present the synovial tissues in this case also showed advanced cartilaginous metaplasia (Fig. 9). This contrasts with our findings in twenty-five cases of uncomplicated osteoarthritis in which metaplasia was found in only two. It seems possible that the emphasis which has been laid on this change in many accounts of osteoarthritis may therefore have arisen from a study of Charcot's joints (Nichols and Richardson 1909).

TABLE I

CONTRASTING FEATURES OF SYNOVIAL METAPLASIA AND ARTICULAR DEBRIS WITHIN THE SYNOVIAL MEMBRANE

	Metaplasia	Articular debris
Position	Within the central connective tissue of the synovial membrane	Upon or just below the surface epithelium
Relationship to surrounding tissue	Cartilage, calcified cartilage and bone merges with connective tissue	Clearly demarcated from surroundings. Often dislocated during histological preparation
Staining reactions	Metachromatic staining reactions as in normal cartilage	Only a slight degree of metachromatic reaction (similar to degenerate cartilage)

Histological examination of the twenty-five cases that form the basis of this study has disclosed debris in twenty-three. In most cases the debris contained both cartilage and bone, but in five only bone fragments were found. In some they were visible in the first histological section examined, but in others multiple sections were required to demonstrate their presence. Both the cartilaginous and bony fragments are found more commonly where there is hyperplasia of the surface cells and villous proliferation of the synovial membrane. For this purpose it is important to take the specimens from areas showing the greatest amount of synovial congestion and hyperplasia, which as already mentioned are usually to be found below the neck of the femur. Synovial membrane from this area, behind more often than in front of the transverse plane, contained the greatest amount of debris when several specimens from different parts of the joint cavity were examined. Gravity may be the factor which directs the fragments to the synovial recesses of this part of the joint.

I was unable to demonstrate these particles in two of the joints examined. In one of these the capsule and synovial layers were so welded together by scar tissue that little of the synovial lining could be recognised with certainty. No explanation can be offered to account for the apparent absence of debris in the other case.

THE RELATIONSHIP BETWEEN JOINT DEBRIS AND CAPSULAR FIBROSIS

It must now be considered whether a relationship exists between joint debris and capsular fibrosis. Observation at operation suggests that there is a relationship between the degree of joint destruction and the extent of the capsular change. This impression accords with the descriptions of the morbid anatomy of the disease; thickening of the capsule is associated with relatively advanced cartilage degeneration (Nichols and Richardson 1909, Collins 1949). On the other hand we have observed synovial hyperplasia in the joint of a young man showing evidence of very early osteoarthritis due to coxa vara. Synovial hyperplasia occurs readily in response to blood in the synovial cavity, and Key (1929, 1932) has shown, experimentally and in a study of haemophiliac arthritis, that sustained or repeated synovial hyperplasia

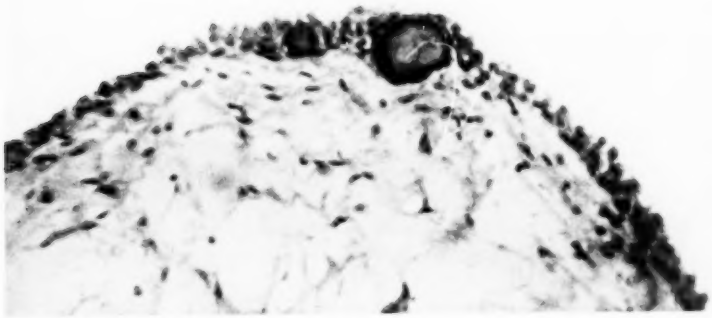

FIG. 10

Synovial membrane of rabbit four weeks after injection of cartilage fragments. Two of the fragments are seen just below the surface layer, the cells of which show some hyperplasia (× 225).

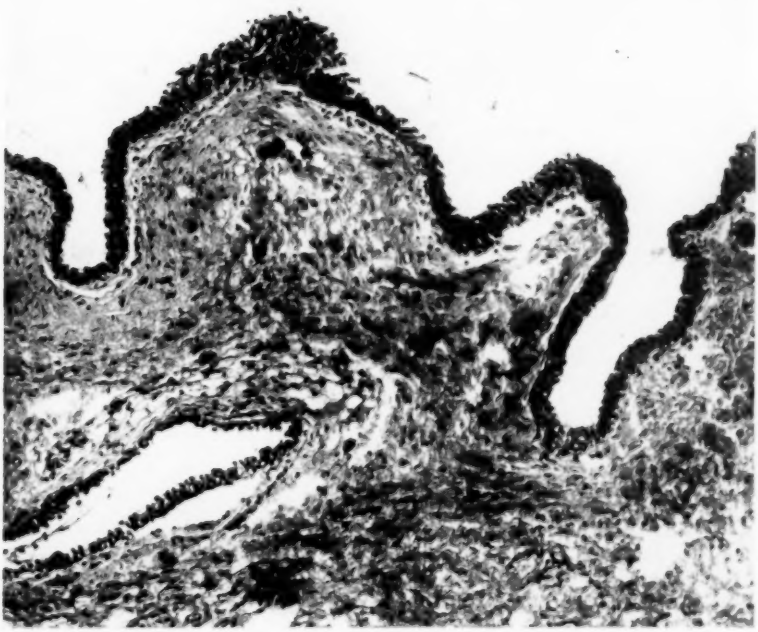

FIG. 11

Synovial membrane of rabbit four weeks after injection of cartilage fragments. This field is adjacent to that shown in Figure 10. Note the generalised synovial hyperplasia and the fibroblastic response in the deeper layers (× 112).

leads to subsynovial fibrosis. The presence of haemosiderin, however, is not an outstanding feature of osteoarthritis and it seems unlikely that all the villous proliferation and fibrosis could be a reaction to haemorrhage. Similar changes have, however, been demonstrated by Key after the injection of Indian ink. Hultén and Gellerstedt (1940) were the first to observe that a cartilage-like substance appeared beneath the synovial surface in osteoarthritis. They introduced fragmented articular cartilage into the joints of animals and demonstrated a progressive fibrosis in response to repeated injections. Their experiments also showed that fresh autogenous and homogenous cartilage fragments were engulfed by the synovial membrane and remained beneath its surface, undergoing disintegration and digestion within a few days.

In collaboration with Dr H. A. Sissons, I have undertaken a similar experimental study to confirm this work and to investigate the fate of fresh homogenous cartilaginous and bony particles injected into the knee joints of rabbits. A single injection of finely ground material was made into the knee joints of eight young rabbits—bone on the one side and cartilage on the other. There was no untoward reaction or sepsis. The results (in contrast to those of Hultén and Gellerstedt) indicated that a fibroblastic reaction occurs in response to only one injection, and that debris and consequent synovial hyperplasia persist for at least four weeks. Figures 10 and 11 show specimens removed from a rabbit killed four weeks after the injection of cartilage particles. Figure 10 shows two fragments lying in a position like that observed in the human material, and Figure 11 is an adjacent low-power field which demonstrates the synovial hyperplasia and the fibrosis in the subsynovial layer. A similar result was obtained from the injection of bony particles.

The rate of removal of debris from a joint must be further considered. It is doubtful whether the debris disappears rapidly in osteoarthritis, for the recognition of the fragments would then be extremely unlikely. Their presence suggests either that the synovial membrane becomes progressively less efficient as a scavenger, or that degenerate articular cartilage, and especially the spicules of bone, are more resistant to the process than the healthy articular cartilage used in the experiments. Persistence of the debris would serve to sustain the synovial hyperplasia and thereby to increase the consequent fibrosis.

In summary, it is concluded—on the basis of observations at operation, microscopic study and animal experiment—that joint debris not only accompanies capsular fibrosis but also plays a part in its production.

THE RELATIONSHIP OF THE SYNOVIAL AND CAPSULAR CHANGES TO THE CLINICAL FEATURES

Surgeons have long suspected that the capsule contributes to both the symptoms and the signs of osteoarthritis and have consequently excised it, in whole or part, in the course of operations upon the hip joint. Some, especially Gade (1947), have credited it with a dominant role. An attempt will be made here to correlate the clinical manifestations of pain, deformity and selective loss of movement with the observed pathological abnormalities in the joint capsule.

It has been found that three factors—deformed bone, fibrotic muscle and contracted capsule—all play a part in maintaining such deformity as persists when the patient is examined under general anaesthesia.

The bony element is usually considered to be late and relatively unimportant, being dependent upon contact between large marginal osteophytes and on gross changes of contour such as may occur when osteoarthritis follows a displaced capital epiphysis. This can be demonstrated readily at operation by moving the hip joint under direct vision after removal or incision of the capsule. Then the main limiting structure is found to be shortening of muscle, a shortening due to the contracture which may occur in any muscle that actively determines the direction of long-standing deformity in any joint (Steindler 1950). This contracture is, however, the secondary effect rather than the cause of the other deforming factors. Only if

the deformity is severe or long-standing will the adductor muscles prove to be tight on abduction under anaesthesia.

The effect of capsular shortening upon hip joint movement can be understood only when the functional anatomy of the capsule is studied by dissection of fresh cadavers. These dissections show that all parts of the capsule are tight in the position of full extension associated with some abduction and slight medial rotation. This fact was described by Walmsley (1928), who also pointed out that in this position there is greatest bony contact and stability between femur and pelvis. It is the position adopted when weight is carried on one leg, and it allows tilting of the pelvis and locking of the knee to occur readily. Walmsley also emphasised that flexion from this point is accompanied by progressive relaxation of the capsule. Medial rotation is brought to a halt by tension upon the posterior and inferior capsule, and abduction by the inferior capsule alone. Adduction and lateral rotation tighten the superior and anterior parts of the capsule respectively. It is also evident that for unhampered movement all parts of the capsule must move freely: this free mobility is particularly necessary posteriorly where the capsule is merely a thin membranous layer in contact with its reflection covering the femoral neck. We have confirmed these statements by dissections of fresh cadaveric hip joints.

Shortening of any part of the capsule will cause a loss of full extension because in this position all parts of the capsule should be tight. Shortening of any part will therefore check the full development of tension elsewhere and in consequence prevent extension. Should this shortening develop in the inferior part of the joint (which deals with the greatest amount of joint debris and which in consequence undergoes the earliest fibrotic changes) a loss of medial rotation and wide abduction will accompany or follow this loss of extension. Intra-articular adhesions in this area will have the same consequences. Flexion from the horizontal plane, during which the capsule is progressively relaxed, will remain free. Continuation of this restricting factor will clearly produce an actual deformity in the opposite direction—namely, flexion, adduction and lateral rotation. Limitation of adduction and lateral rotation will not occur until the capsular changes have spread to involve the superior and anterior aspects of the joint.

This early loss of extension may have an important influence upon the progress of the disease. As already mentioned, Walmsley emphasised that the surfaces of the femur and acetabulum were in greatest contact in this weight-bearing position. With loss of extension the area of contact will diminish progressively as the deformity increases. Consequently the body weight will be carried through a smaller area of articular cartilage, this will wear out more quickly and the accelerated detachment of debris will speed capsular fibrosis.

This description of the functional effects of capsular shortening has been verified at operation in several advanced cases. An exposure of the hip from behind, with vertical division of the grossly thickened posterior and inferior capsule, may be found to release the movements of medial rotation and abduction within the limits set by the contracted muscles. An anterior approach with transverse division of the lower part of the anterior ligament will often overcome the greater part of a flexion deformity. This approach combined with tenotomies also allows an assessment of the amount of the deformity that is caused by contracture of the flexor and adductor muscles. It should be emphasised, however, that a full range in any direction could seldom be obtained by selective capsular incision alone. In most, capsular changes had become so generalised when operation was performed that wide excision was required before a range of movement approaching the normal could be restored.

In this discussion the capsular abnormality has been ascribed to the progressive fibrosis secondary to sustained synovial hyperplasia and it has been regarded as a contributory cause of deformity. It is possible, however, that the capsular abnormality has an extra-articular cause, such as muscle spasm. Although operations performed for the correction of

fixed deformity caused by spasm or muscle imbalance may show the capsule to be shortened on the convex side, it is not as thickened and fibrotic as the capsule in osteoarthritis (Fig. 2). In addition there is neither a synovial abnormality in these joints nor a tendency for other areas of the capsule to become involved. Lastly, as Collins (1949) points out, intra-articular adhesions never form secondarily to deformities from muscle imbalance or paralytic disorders, whereas they are common in osteoarthritis. It may be concluded that, while periarticular factors may encourage shortening of the joint capsule in osteoarthritis, they do not bring about the generalised fibrotic thickening and synovial changes that occur and which precede contracture in the surrounding muscles.

The dominant deforming factor in most cases is muscle spasm. Spasm is a voluntary and involuntary response to movements which if continued would be painful, so that both pain and spasm may have a common origin. The intimate innervation of articular structures was fully discussed by Gardner (1950). He concluded that the joint capsule is richly supplied by somatic and autonomic fibres. Although nerve plexuses are seen in the synovial membrane their nature is obscure. Kellgren and Samuel (1950), studying pain sensibility in the human knee joint, commented upon the sensitivity of the capsule, which contrasted strikingly with the scattered areas of pain appreciation in the synovial membrane and the insensitivity of articular cartilage. During an operation upon a knee joint under local anaesthesia the writer found traction upon the capsule a particularly painful manoeuvre.

It has already been suggested that shortened and thickened capsule becomes tense prematurely and so reduces the range of hip joint movement. It is now suggested that if movement continues beyond this limit imposed by the shrunken capsule, and if at the same time body weight is added to the movement, a considerable traction force is likely to fall upon this abnormal ligament, thereby producing pain and protective muscle spasm. Intra-articular adhesions will tend to reinforce the effect of capsular fibrosis in a similar way. Intra-articular and intracapsular novocain injections will often temporarily reduce both this pain and spasm.

Considering once again the lower part of the joint which is supplied mainly by the obturator nerve, but also by the nerve to quadratus femoris behind and to pectineus in front (Gardner 1948), I find in this hypothesis of traction pain a logical explanation for the occurrence of reflex spasticity in the muscles supplied by these nerves. The deformity produced by this spasm is furthermore in the same direction as that which I have shown to follow shortening of the capsule in the same area of the hip joint.

Support for this interpretation of the origin of reflex spasm is provided by the familiar clinical test for adductor spasm. An abduction or medial rotation strain is resisted by the postero-inferior capsule of the joint. If this part of the capsule is contracted the tension in this area produced by these movements may give rise to pain and spasm, whereas passive flexion loosens the capsule and so may often be accomplished without spasm. Adduction and lateral rotation do not tend to stretch the inferior part of the capsule and are consequently less likely to induce pain and spasm.

A RADIOLOGICAL SIGN

Further evidence of capsular shortening is provided by a radiological sign. New bone formation visible below the femoral neck was seen in the radiographs of thirty-three out of seventy-three consecutive patients with osteoarthritis of unknown origin subjected to operation. This sign was fully described by Wiberg (1939) in congenital subluxation of the hip. He said that new bone formation occurred behind the lower margin of the femoral neck, an observation which my operative and radiological investigations confirm. He regarded it as a buttress formed in response to abnormal stress. Although in idiopathic osteoarthritis it occurs more commonly when subluxation is present, it may occur when subluxation is minimal

FIG. 12

FIG. 13

Figure 12—Idiopathic osteoarthritis of the hip. A considerable amount of new bone is present below the neck of the femur in spite of only slight subluxation. There is calcification in the capsule above the neck. Figure 13—Idiopathic osteoarthritis of the hip. There is new bone below the neck of the femur without subluxation of the hip joint.

FIG. 14

FIG. 15

Figure 14—Condition of hip five months after open reduction for traumatic dislocation. The new bone visible below the neck of the femur appears to lie on the deep surface of raised periosteum. There had been no weight bearing. Figure 15—Osteoarthritis of the hip. The new bone seen below the neck of the femur has appeared within five months of an exploratory operation and partial capsulectomy.

or absent (Figs. 12 and 13). I believe that this bone is subperiosteal and is caused by elevation of the periosteum away from the neck of the femur by a traction force transmitted through the postero-inferior capsular reflection (retinaculum). In support of this view I submit, first, that capsular tension is most likely to develop here when subluxation occurs and, secondly, that similar changes may follow traumatic dislocation (Fig. 14) and exploratory operations upon the hip when the capsule has been stretched by bone levers (Fig. 15). Furthermore, of the thirty-three patients presenting this feature twenty-six had an adduction deformity, or had lost power to abduct beyond the neutral position—a sign which it is suggested indicates marked capsular shortening in the inferior part of the joint capsule.

DISCUSSION

An attempt has been made to correlate the symptoms and signs of osteoarthritis with the pathological changes that have been found in joint capsules removed from the hip joints of patients sufficiently disabled to require operative treatment. It is well recognised, however, that many patients in whom there is radiological evidence of advanced osteoarthritis, suffer surprisingly little pain. They present an important clinical problem and have been questioned and examined with particular care.

With advanced radiological changes movement is always restricted, but pain may be absent. Its source must therefore be in structures scarcely manifest in radiographs. I suspect stretching of the shortened capsule, as occurs when an attempt is made to force movement in such a joint. I suggest that the reason why a McMurray's osteotomy may relieve pain is that the upper fragment takes up the position of deformity which the capsule dictates and so protects it from much of the strain to which it was previously exposed. Similarly replacement of the femoral head by a prosthesis may shorten the distance between the fixed points of the capsule and thus relieve pain, even if the capsule is not excised. Such a prosthesis will also remove the main source of joint debris.

Rest is known to relieve the pain of most osteoarthritic joints. It seemed desirable therefore to enquire into the amount that patients, with radiological evidence of marked osteoarthritis but with little pain, demanded of their hip joints. By this means I have found an explanation for the absence of pain in many patients with osteoarthritis. On careful questioning, most mentioned a reduction of their activities to conform to the standards set by their hip joints. In some this was a conscious restriction; in others it occurred from advancing age or was imposed by some coincidental disease such as cardio-vascular failure. Patients suffering from osteoarthritis of both hips may have no pain in one side because the disability caused by its fellow has restricted their activity greatly. A pain-relieving operation on the painful hip often leads to pain in the previously symptomless hip when activity is increased.

Some patients complain of stiffness only. Most of these have had pain in the past which has been forgotten or is now regarded as unimportant. Among them some have noticed their disability after a period in bed for some other condition. Their deformity is often severe, and movement reduced to a few degrees of flexion only. Lastly there are those whose pain is referred to the knee or low back (Law 1952), and those who make light of their troubles.

In considering the symptoms of osteoarthritis it is also important to appreciate that the degenerative changes that occur in the articular cartilage and subchondral bone with ageing are identical with those in osteoarthritis. Bennett *et al.* (1942) have studied the changes in previously symptomless knee joints obtained at necropsy. In subjects of between eighty and ninety years old they found marked degenerative lesions which were very like those in younger individuals operated upon for osteoarthritis.

It has already been suggested that restriction of activity or stiffness tolerable at eighty may be less readily accepted at the age of fifty, but it is possible that the speed with which

debris is cast into the joint cavity influences the symptoms arising in the joint. Bennett *et al.*, although aware of the work of Hultén and Gellerstedt, did not describe debris within the synovial membrane unlike Horwitz, who found these fragments twice in clinically osteoarthritic knees during his investigation of Charcot's joints. These observations, in addition to those presented in this communication, suggest that joint debris may become apparent only when it becomes dislodged at an abnormal rate or in abnormal quantity. The scantier and slower physiological loss of cartilage associated with ageing may be digested by the synovial membrane, as it occurs, within the recesses of capsular reflection. Consequently it may escape recognition, and it will induce capsular fibrosis at a much lower rate. Under these circumstances a balance may be set between increasing capsular changes on the one hand and decreasing activity on the other so that a joint, though degenerate by radiological and pathological standards, may continue to serve well. Anything (such as dysplasia of the hip joint) which accelerates the formation of joint debris will tend to hasten the onset of capsular shortening by the mechanism that has been described. In this way the patient may present at an early age the clinical features of severe osteoarthritis, but a radiograph showing only localised diminution of joint space and subchondral sclerosis.

In conclusion, it is submitted that this interpretation of the etiology and effect of capsular fibrosis may have an application in osteoarthritis of other joints. In hallux rigidus joint debris and synovial hyperplasia have been found within the reflection beneath the head of the metatarsal bone. Any shortening or adhesion of the capsule in this position would cause a loss of dorsiflexion, though plantar flexion would remain unaffected.

SUMMARY AND CONCLUSIONS

1. The synovial membrane and capsule in osteoarthritis of the hip have been studied in twenty-five cases. Dissections have been made on fresh cadavers to establish the normal structure and function of these tissues at different ages.

2. Fragments of bone and cartilage were found beneath the synovial surface in twenty-three cases of the twenty-five cases of osteoarthritis.

3. The source of these fragments is the degenerate articular surfaces.

4. The fibrosis of the synovial membrane and capsule follows the synovial hyperplasia which accompanies the phagocytosis of these fragments.

5. A similar histological picture has been produced by injecting fragmented cartilage into the knee joints of rabbits. The injected fragments are found beneath the surface, and synovial hyperplasia is followed by subsynovial fibrosis.

6. The greatest amount of this joint debris is found in the lowest part of the joint cavity.

7. The joint capsule is particularly sensitive to traction.

8. All parts of the capsule are tight in extension, which is the weight bearing position.

9. Fibrotic shortening of the capsule in the lowest part of the joint cavity explains many of the symptoms and signs of the disease: pain is caused by an attempt to stretch the capsule; muscle spasm occurs in the muscles supplied by the sensory nerves of this part of the capsule; extension, medial rotation and abduction, which tighten this area, are lost first; progressive shortening causes deformity in the opposite direction, namely flexion, lateral rotation and adduction; the loss of extension causes a more rapid wearing of articular cartilage on weight bearing; subperiosteal new bone is formed on the under-surface of the neck of the femur.

10. The symptomatology is discussed.

I wish to thank Dr H. A. Sissons for his collaboration and valuable assistance in the experimental and pathological aspects of this study, Mr H. J. Seddon for his helpful criticism and assistance throughout, and Mr A. T. Fripp and Mr K. T. Nissen for their interest and the provision of pathological material. Mr B. H. Burns and Mr R. H. Young have very kindly allowed me to examine and operate on some of their patients and have given me considerable help and encouragement.

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THE BONE CYSTS OF OSTEOARTHRITIS

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Rounded areas of translucency in the bones forming an osteoarthritic joint are well known to radiologists and to orthopaedic surgeons. They are not given much prominence in pathological accounts; their formation is vaguely ascribed to degeneration in the bone in keeping with the degeneration in the neighbouring cartilage. Their frequency was given by Plewes (1940), from clinical and radiological studies, as thirty-two in 242 cases; he also drew attention to their situation in areas of greatest bone sclerosis and greatest loss of "joint space," and to their frequently paired or "kissing" position on either side of the joint line. Collins (1949) described them as incidents in the remodelling of the trabeculae—"a concentric arrangement of healthy trabeculae around an enlarged marrow space filled with ordinary adipose tissue."

The presence of these cysts is often indicated clinically by severe pain in the joint, and in the cases selected for surgical treatment of osteoarthritis the cysts are neither so rare nor so incidental as has been suggested. They have been present in eleven of the last nineteen heads of femur and in one of the last three patellae excised for osteoarthritis and examined in this department. I have found other examples in an osteoarthritic pisiform bone, and in a fractured carpal scaphoid excised ten years after the injury; and in the course of routine post-mortem examinations of patellae they were found in three of ten consecutive bones, and in one of the only two severely arthritic heads of femur in a series of a hundred; another was an incidental finding on microscopy of the acromio-clavicular joint of a patient with ankylosing spondylitis.

The cysts appear to the naked eye as grey gelatinous rounded spaces from a millimetre up to 2·5 centimetres in diameter; the large cysts, over 1 centimetre across, are found only in the femoral head. The cysts are usually multiple—ten were found in one patella—and surrounded by a zone of dense bone up to half a centimetre thick; some are multilocular. A good example of a large cyst is shown in Figure 1, where the greater part of the femoral head is seen to be involved. The smaller cysts (Figs. 3 and 5 to 7) always lie in the bone immediately adjacent to the joint space, and are often pyriform, the pointed end towards the joint. There is always one place where the cyst comes close to the joint cavity, and in a number of specimens it is possible to demonstrate an opening between the two, usually in the form of a linear fissure. It is the purpose of this paper to suggest that these cysts always take origin in such communications and are not due to primary degenerative changes in the bone.

PATHOLOGICAL OBSERVATIONS

Direct evidence in favour of the hypothesis mentioned above includes the demonstration of an opening into the joint cavity, the finding inside the cyst of fragments of cartilage clearly derived from the articular cartilage, and the similarity between the fluid in the cyst and the synovial fluid.

Openings between cyst and joint cavity.—Patent openings can be found in a number of cysts, though they may be very oblique and tortuous; a simple example is shown in Figure 2, which is a higher power photomicrograph of the mouth of the cyst shown in Figure 1. Here a direct channel leads past the broken articular lamella of an osteoarthritic femoral head into one loculus of a multilocular cyst. The opening is partly filled with fibrocartilaginous material from other parts of the articular surface, which has closed the entry to a second loculus.

Such secondary closure of the articular surface is much more frequently found than the patent opening; more careful assessment of the detailed structure of the articular lamella is then necessary to prove that an opening has been present earlier.

Cartilage fragments within the cysts—Occasionally it is possible to recognise in the cyst pieces of cartilage that are clearly derived from the hyaline articular cartilage. Some cartilage

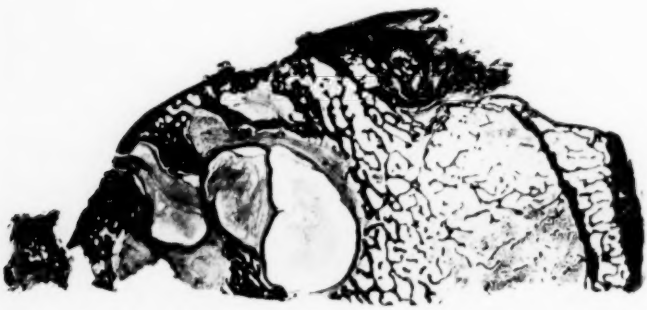

FIG. 1

Case 1. Coronal section of head of femur. A large system of cysts replaces much of the femoral head. (Van Gieson's stain. × 2.)

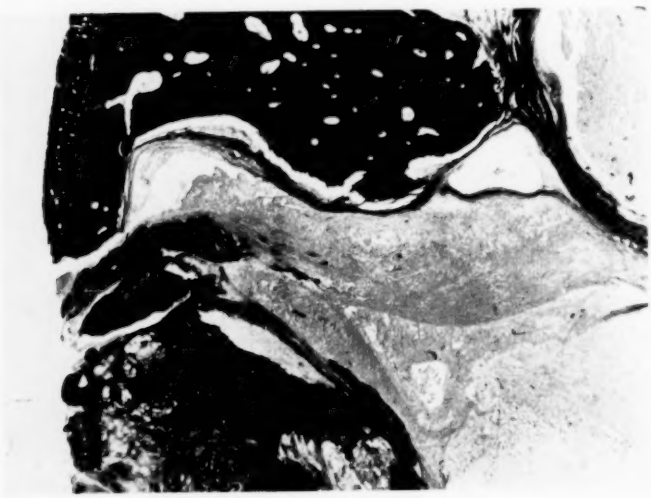

FIG. 2

The same. Higher magnification showing the opening of a cyst through the articular lamella. Dense bone on one side of the cyst, fibrous tissue, fibrocartilage and woven bone on the other. (× 12.)

found in this situation cannot be certainly assigned to this origin and may be metaplastic, but the two examples shown in Figures 3 to 5 are unequivocal. The specimen was taken from the acromio-clavicular joint, which showed fairly well marked fibrillation of its cartilage, though none of the changes of the ankylosing spondylitis which had brought the patient to hospital. In Figure 3 the bilocular cyst is seen with the gap in the (nearly black) cartilage

now plugged by new fibrocartilage and bone. The higher magnification of Figure 4 shows clearly recognisable cartilage cells in the debris floating loose in the corner of the upper cyst; this is even clearer in the original slide with the metachromatic staining by toluidine blue. It is particularly to be noted that in this cyst, in the fluid contents, the cells of the cartilage

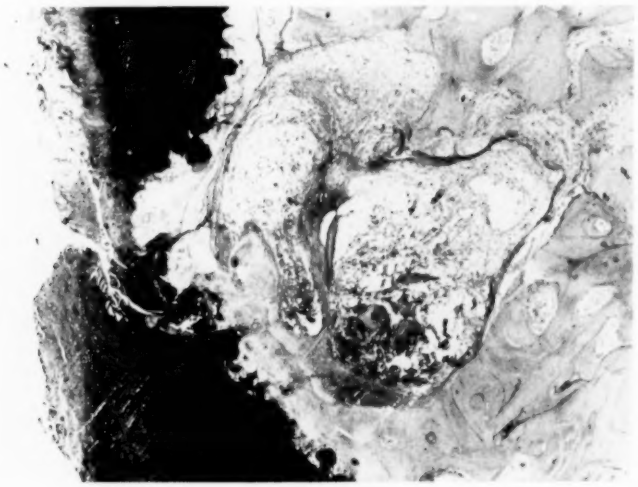

FIG. 3

Acromio-clavicular joint, showing a bilocular cyst, the gap in the articular lamella is closed by bone and fibrocartilage. (Toluidine blue. × 21.)

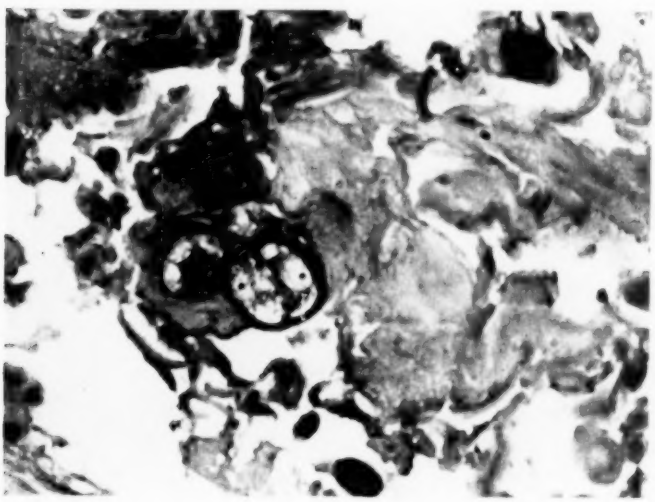

FIG. 4

The same. Detail of the detritus in the corner of the cyst. Note the cartilage cells. (× 670.)

are fresh and alive. In the second example (Fig. 5), the cyst was found in a pisiform bone which was denuded of articular cartilage. The cyst has become completely filled now with fibrous tissue and its original content of fluid can only be guessed at; but in this fibrous tissue there is a flake of cartilage whose form proves its origin from the surface of the joint.

FIG. 5

Pisiform bone. Eburnation of the joint surface, with a fibrous plug at its edge leading into a fibrous cyst. In the middle of this a strip of articular cartilage, with the cells dead. (Van Gieson. × 21.)

FIG. 6

FIG. 7

Figure 6.—Patella. Fracture in articular lamella plugged by displaced tongues of fibrillated cartilage with new bone deep to them, bone fragments being removed in depths by osteoclasts. (Van Gieson. × 52.)
Figure 7.—Scaphoid. Cyst pointing to its original opening through the fracture line into the joint; opening now closed by reaction, and new bone also shown in the cyst wall. (Van Gieson. × 60.)

The cells in it are dead, but their spaces can be faintly made out. The finding of living cartilage in fluid cysts and dead cartilage in fibrous cysts is strong evidence that the fluid forms before the fibrous tissue, and is not, as has been suggested, a secondary development in a fibrous area in the bone.

Occlusion of the opening is brought about by the formation of fibrocartilage and new woven bone near the throat of the opening, which interrupts the pattern of the articular lamella so clearly that it can usually be recognised as new. Immediate occlusion is found also after the impaction into the opening of plugs formed from the degenerate cartilage when this has not been completely eroded. Such a picture is found in Figure 6, in which there is a clean fracture through the articular lamella plugged by fibrillated cartilage with its characteristic hypertrophic groups of cells, under which new woven bone has formed and re-established the articular surface. Deeper in, replacement by fibrous tissue is complete, except for the fragments of broken bone at the bottom undergoing resorption. The importance of this occlusion of the surface opening is very great, for it enables granulation tissue to develop in its appropriate environment, and in time fibrous tissue may fill the cyst, though densely encapsulated loculi of fluid may persist even when the surrounding bony shell is complete. Nevertheless on detailed examination openings or traces of openings (if the features described are accepted as such) can be made out in all cases.

Nature of the contained fluid.—The glairy yellowish-green fluid found in the cysts is entirely in keeping with a derivation from the synovial fluid. The mononuclear cells in it resemble detached synovial cells, and staining reactions show mucopolysaccharide in both cells and fluid. These cysts, unlike others found in bone, do not commonly contain blood pigments, cholesteride crystals or fibrin.

DISCUSSION

Considerable indirect evidence supports the hypothesis that cysts arise from intrusion of synovial fluid into the bone at the joint surface.

Firstly, it has been noted that small cysts are found in the subchondral bone and large cysts extend more deeply. If the cysts were due to bone degeneration, it might be expected that small early foci would be found on routine examination of the deep bone, but such foci have not been found nor are they described in the literature. Again, the bone surrounding the cysts is always more or less sclerotic, and often shows active bone formation, a sequence of changes difficult to account for as a degeneration. Moreover it is unusual to find areas of osteoclastic resorption in the walls of the cysts, and when they do occur they affect only a small part of the circumference.

The cartilage over the cysts is never normal, though the stage of its degeneration varies from quite early vertical splitting to complete erosion. The cysts are not found in eburnated bone, probably because of its rigidity, and because the marrow spaces in such bone are sealed off from the joint cavity by new bone formation; but cysts with a vent in the cartilage at the side may burrow extensively under eburnated bone.

There is therefore good reason to believe that the penetration of synovial fluid is likely to occur in the regions where the cysts are found, and sometimes there is visual proof that it has occurred.

On the hypothesis that intrusion of synovial fluid into the interstices of the bone occurs, the further developments that would be anticipated are in fact much the same as those that have been observed, when allowance is made for the varying size and duration of the opening. Thus, with a persistent opening the uniform fluid pressure would tend to convert the irregular outlines of the marrow spaces into the smoothly rounded or pyriform outlines characteristic of the cysts, with the narrow end of the cyst towards the joint space where expansion is limited by the strong articular lamella. Around this pressure zone would be expected dense bone formed partly by bodily displacement of the trabeculae, partly by new bone formation in response to the strain. Such sclerosis around the cysts is one of their most conspicuous

features, and one most hard to explain on a hypothesis of degeneration. The larger cysts are almost confined to the head of the femur; elsewhere it is unusual for them to reach a diameter of a centimetre. The rounded outlines suggesting fluid pressure, the increase of synovial fluid in osteoarthritis, the pressure built up in the hip by the weight of the body, the extremely tough capsule of that joint compared with that of the knee, and the clinical relationship between painful hips and cystic bone changes, form a chain of evidence of some strength in favour of the hypothesis that these large cysts are virtually internal incomplete fractures of the bone brought about by the slow persistent transfer of pressure from the synovial fluid to the weak internal cancellous trabeculae unaccustomed to such lateral thrusts. Some evidence in support of this hypothesis is available from clinical cases.

CASE REPORT

Case 1 A woman aged fifty-nine, who had had pain in both hips for eighteen years, was seen with a view to cup arthroplasty. The hips showed radiographic evidence of severe degenerative arthritis, and there were small areas of translucency in the upper part of the head of the right femur and the opposite surface of the acetabulum. The left hip, at that time the more painful, showed no cysts. She was unwilling to have an operation. Two years later she fell downstairs, twisting her right foot and wrenching the hip. This hip then became very painful, keeping her awake at night and she requested surgical relief. A Judet arthroplasty was performed. The excised head showed no ordinary callus or fracture but the unusually large system of cysts with the patent opening illustrated in Figures 1 and 2. It is true that the original cysts might have advanced in the two years, and that in any case they formed a zone of weakness through which any subsequent fracture might be expected to run, but the correlation between injury, severe pain and unusually extensive cyst formation is quite often observed.

Cysts will not necessarily be formed in every case in which breaches occur in the articular lamella, but only when such breaches remain open to the synovial fluid and in particular when the fluid is under pressure. The cyst (already mentioned) in the acromio-clavicular joint developed in a patient whose lower limbs were ankylosed and who got about on crutches. He had unusual muscular development of the arms and probably there were unusual strains on the acromio-clavicular joints. The joint examined showed cyst formation on both sides at one point in the articulation; this feature, already referred to, is related partly to the usual congruence of osteoarthritic changes on the opposing faces, and partly to strains developing at right angles to the plane of the joint, which will be as likely to fracture both articular lamellae as one. But it is not easy on a hypothesis of degeneration to account for such paired foci in the deeper bone.

Once the opening becomes occluded—and this may occur at any stage in the development of the cyst—fresh synovial fluid cannot enter and granulation tissue can develop without the competing pressure and unsuitable environment of the joint fluid. As long as fluid is present, the marrow spaces are filled with fibro-myxomatous tissue, which in some circumstances may become cartilaginous; but once the fluid is encapsulated ordinary fibrous tissue forms and has a tendency to ossify, in part as woven bone, but also with lamellar apposition to pre-existing trabeculae. This process does not usually go on to complete obliteration of the cyst, but ends by forming a rounded thick-walled bone space with the mucinous marrow and occasional encysted fluid collections described by other authors.

Further support for the fluid hypothesis comes from a case in which the fluid gained access to the interior of the bone through a fracture line.

CASE REPORT

Case 2 A healthy man of twenty-two fractured his carpal scaphoid. It remained ununited and was excised because of persistent non-union ten years after the original injury. The proximal fragment was found to have undergone avascular necrosis, with survival of the cartilage. In the other half a typical closed mature cyst was present; there was much new bone around the throat of the cyst, but it was possible to identify a clear line of old communication now filled with bone and fibrocartilage through the fracture into the joint (Fig. 7). There was no evidence of degeneration in the cartilage or in the rest of the bone.

It is possible that these traumatic cysts are less rare than they are thought to be, for it is clearly only occasionally that a fissure will neither completely detach a piece of bone nor remain unoccluded by callus long enough to allow the formation of a cyst visible on radiography; and such bones are seldom excised for close morbid anatomical study. The coarser fractures do not provide the necessary blind cavity for the fluid to be forced into, and in nine heads of radius and four patellae excised for fracture I have found no cyst.

Objections to the alternative hypothesis.—The alternative view, namely that these fibrous and myxomatous changes are primary, leading to accumulation of fluid and so to cyst formation, involves several difficulties. The absence of osteoclastic activity in any quantity is probably the least, for the osteoclast is believed to be short-lived. The formation of rounded spaces out of the irregular marrow spaces suggests the agency of fluid, but these spaces are often round when they are fibrous. Concentric zones of fibro-myxomatous changes in the marrow and bone-forming reaction would be improbable. The openings into the joint would imply either trauma consequent on cyst formation or the rupture of the cyst through the overlying dense articular lamella, a process for which the necessary forces do not seem to be available. Fractures undoubtedly occur through the articular lamella in relation to cysts, but for reasons given I believe the fracture antedates the cyst. The presence of living cartilage derived from the articular surface in open fluid-filled cysts, and of dead cartilage in the fibrous cysts, appears to be conclusive.

Osteoarthritic changes may legitimately at present be called degenerative so far as they affect the superficial part of the cartilage; but the removal of the fragmented cartilage and many if not all of the bony changes which are responible for the greatest deformity are clearly traumatic or reparative. It is desirable whenever possible to replace the vague conception of degeneration by precise chemical or mechanical changes; and it is the purpose of this paper to do so by pointing out that the cyst formation responsible for a great deal of the deformity and pain of an osteoarthritic joint is in fact traumatic and not degenerative in the accepted sense of the word.

SUMMARY

1. The bone cysts of osteoarthritis are found in relation to defects in the watertight layer between the joint space and the cancellous bone; these defects are sometimes obvious openings, but more often they are openings closed by fibrous tissue, fibrocartilage or new bone. The small cysts lie close to the surface. Their rounded outlines suggest the agency of fluid pressure in their formation, and the fluid and cells found in the cysts are compatible with origin in the joint space and articular cartilage.

2. The hypothesis is advanced that the cysts are formed by the intrusion of synovial fluid under pressure into the substance of the bone, and the sclerosis around by displacement of the trabeculae and their reinforcement by new bone.

3. The objections to the hypothesis that the cysts represent a primary degeneration in the bone are discussed.

I wish to acknowledge the kindness of the orthopaedic surgeons of the London Hospital for permission to study their material, and the technical and photographic assistance of the staff of the Bernhard Baron Institute.

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RECOVERY IN PARTLY PARALYSED MUSCLES

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Until recent years it was widely held that damage to part of the nerve supply of a voluntary muscle had a permanent effect and that the surviving nerve fibres were unable to reinnervate muscle fibres deprived of their nerve supply. It was assumed that the only possibility of recovery of power in the muscle was by hypertrophy of muscle fibres whose nerve supply had escaped damage.

The problem has recently been approached by both physiological and histological methods. Van Harreveld (1945) showed that the contraction force of incompletely denervated muscles begins to improve about two weeks after operation and increases for six months. Edds (1950) and Hoffman (1950), in histological studies of rat muscle incompletely denervated by division of anterior primary rami, found evidence of new fibres retracing the empty neurilemmal tubes to the denervated motor end-plates. That a similar process occurs in skin partly deprived of its sensory nerve supply has been shown by Weddell, Guttmann and Gutmann (1941).

It has not yet been generally accepted that surviving axons in incompletely denervated muscle can extend their existing field of innervation by producing new fibres. The problem is of great practical importance, for if this process takes place after an attack of poliomyelitis, and if ways could be found to promote it, a real advance in treatment would be at hand. The aim of this study has been to obtain further histological evidence of the extent and duration of this process: limb muscles of the rabbit have been examined for evidence of the development of new fibres for periods of up to three months after incomplete denervation.

MATERIALS AND METHODS

The extensor digitorum longus muscle of the rabbit was chosen because it is particularly suitable for incomplete denervation. The muscle is supplied by two branches of the peroneal nerve. Incomplete denervation of the muscle was effected by division of one or other of these branches. Precautions were taken to eliminate the possibility of regeneration along the divided nerve. Usually the upper branch, which is the smaller, was divided and the proximal stump crushed and implanted into a neighbouring muscle belly, as far from the distal stump as possible. Care was taken not to handle or damage the blood vessels which enter the muscles with the nerve, thus eliminating the possibility of ischaemic effects on regeneration (Allbrook and Aitken 1951). To divide one of the nerves entering the muscle, the muscle belly was lifted from its bed by a clip placed round the tendon of origin. It seemed possible that damage might be caused to the remaining nerve supply by thus lifting the muscle. In a number of animals mock operations were done, reproducing as exactly as possible the operative conditions without dividing the nerves.

The muscles were removed at periods from two days to three months after operation. They were fixed in a solution containing 10 per cent formalin and 2 per cent pyridine for a minimum period of ten days. Each specimen was cut into two blocks of approximately equal size. The upper and lower tendinous parts were rejected. Each block was cut into as many sections of 50μ thickness as possible. All suitable sections were stained by a modified Bielschowsky silver impregnation technique (Aitken 1950). At least forty sections were prepared from each muscle examined.

OBSERVATIONS

When either of the nerves to the extensor digitorum longus was divided sections made two or three days later showed: 1) intact sprays of fibres approaching motor end-plates;

2) sprays with complete degeneration of all fibres; 3) sprays with one or few surviving fibres, the remainder degenerated; and 4) sprays with one or few degenerated fibres, the remainder intact.

When the upper nerve branch was divided the degenerating nerve fibres were mainly confined to the upper third of the muscle. In the remaining two-thirds the nerve fibres and end-plates were mainly intact. A few intact fibres and end-plates were found in the upper third, and similarly a few degenerate fibres in the lower two-thirds. Scattered throughout the muscle were sprays of fibres in which varying numbers of fibres had degenerated, as in
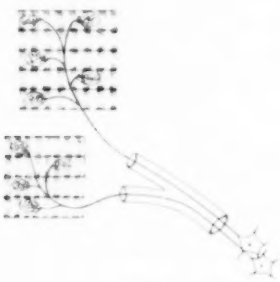
FIG. 1

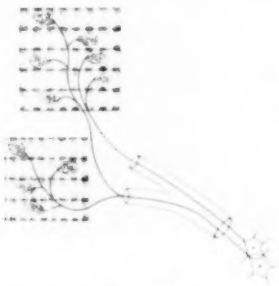

FIG. 2

Figure 1.—Schematic representation of the individual axons in the upper and lower nerve branches to the extensor digitorum longus each supplying groups of muscle fibres. Figure 2.—To show an axon in the lower nerve branch supplying muscle fibres in widely separated parts of the muscle.

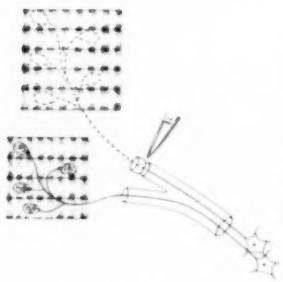

FIG. 3

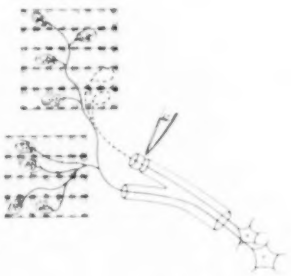

FIG. 4

Figure 3.—To show intact sprays of motor endings and sprays with complete degeneration of all fibres when the upper nerve branch is divided. Figure 4.—The upper nerve branch has been divided; intact and degenerate fibres lie side by side. This is a direct consequence of the intermingling of individual axons within the muscle (cf. Fig. 7).

Figure 6, which shows a terminal spray with one surviving fibre and end-plate. There was no sharp boundary line between the parts of the muscle supplied by the two nerve branches.

These findings indicate that the intramuscular ramifications of the two nerve branches entering the muscle intermingle freely in such a way that it is possible for one parent fibre to innervate muscle fibres in widely different parts of the muscle (Figs. 1 to 4). The motor unit is therefore not confined to single groups of neighbouring muscle fibres, and the individual end-plates in a given zone of the muscle are frequently derived from different parent axons (Adrian 1925, Cooper 1929, van Harreveld 1946, Feindel, Hinshaw and Weddell 1952).

Although these findings have wide implications as regards the structure of the motor unit, the central fact as regards this investigation is that after incomplete denervation by this method there were areas in the muscle where intact and degenerate fibres lay side by

FIG. 5

Several terminal bundles of fibres and end-plates arising from an intramuscular nerve trunk as seen in the normal extensor digitorum longus.

FIG. 6

Three days after incomplete denervation. Terminal spray of fibres with one surviving fibre and end-plate. *n.ep*—normal end-plate; *d.n.f.*—degenerating nerve fibres.

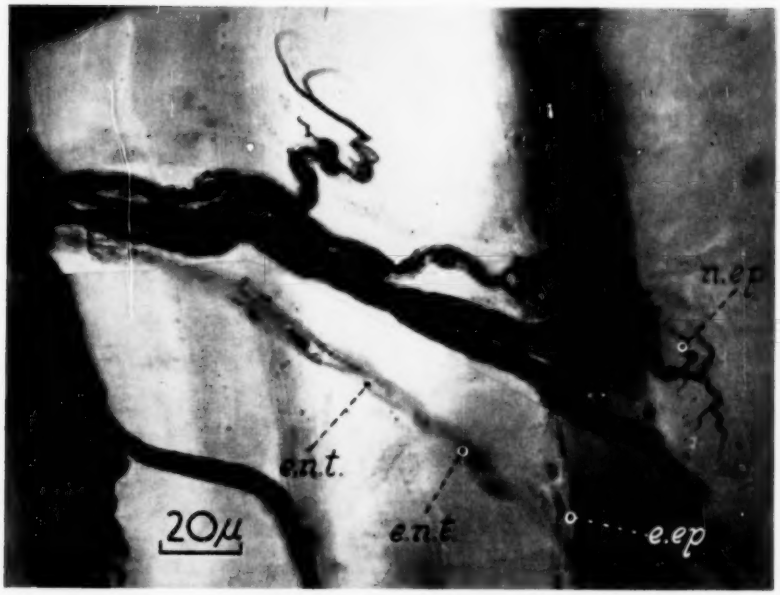

FIG. 7

Three days after incomplete denervation. Empty neurilemmal tubes and motor end-plates are clearly seen. In areas such as this, where normal and degenerated fibres lie side by side, new fine fibres grow out and reinnervate the degenerated end-plates. *e.n.t.*—empty neurilemmal tube; *n.e.p.*—normal end-plate; *e.e.p.*—empty end-plate.

FIG. 8

Four days after incomplete denervation. New fine fibre reinnervating a denervated end-plate. Another denervated end-plate lies immediately adjacent. *ne.f.*—new fibre; *e.e.p.*—empty end-plate.

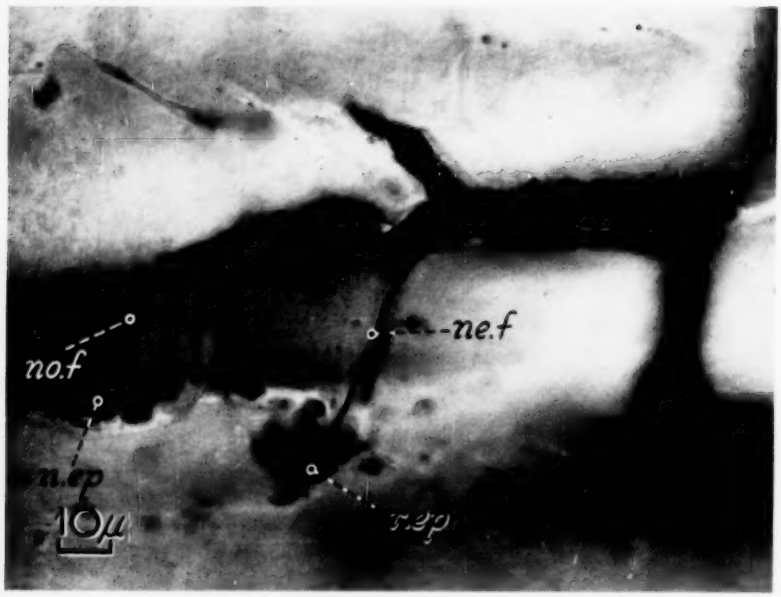

FIG. 9

Four days after incomplete denervation. Reinnervation of motor end-plates by fine collateral fibre. The absence of "claws" in the reinnervated end-plate contrasts sharply with normal end-plate. *no.f.*—normal fibre; *n.ep.*—normal end-plate; *ne.f.*—new fibre; *r.ep.*—reinnervated end-plate.

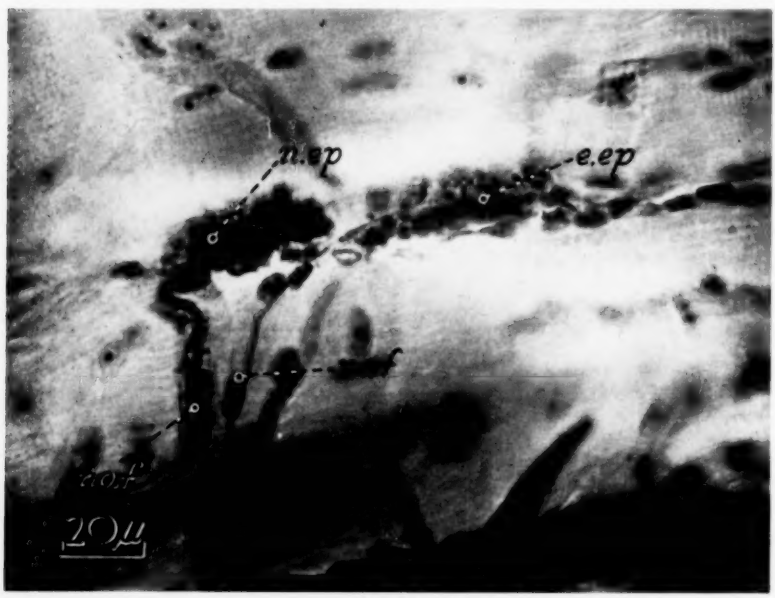

FIG. 10

Seven days after incomplete denervation. Normal fibre and end-plate accompanied by new fine fibre reinnervating a denervated end-plate. Contrast between normal and reinnervated end-plate is striking. *n.ep.*—normal end-plate; *no.f.*—normal fibre; *ne.f.*—new fibre; *e.ep.*—empty end-plate.

side (Fig. 7). This was a frequent finding in muscles up to a week after incomplete denervation. Thereafter degenerate fibres were more difficult to find, though they were observed as late as thirty days after operation.

Growth of new fibres.—Figure 5 shows a normal spray of fibres all intact, and Figure 6 a terminal spray with one surviving fibre and end-plate in a spray. It is in these areas where degenerate and intact nerve fibres lie in close proximity that new fine fibres appear and reinnervate the old end-plates (Figs. 8 to 16). This observation is in accord with those of other workers (Edds 1950). Very fine fibres appear as early as four days after incomplete denervation, and reinnervate denervated end-plates. The point of branching of the residual axons is usually difficult to determine, for they appear to come from far back in the nerve bundles. Nevertheless some preparations show the point of branching (Fig. 16). These fine fibres are not seen in the normal extensor digitorum longus. Terminal outgrowths sprouting from the

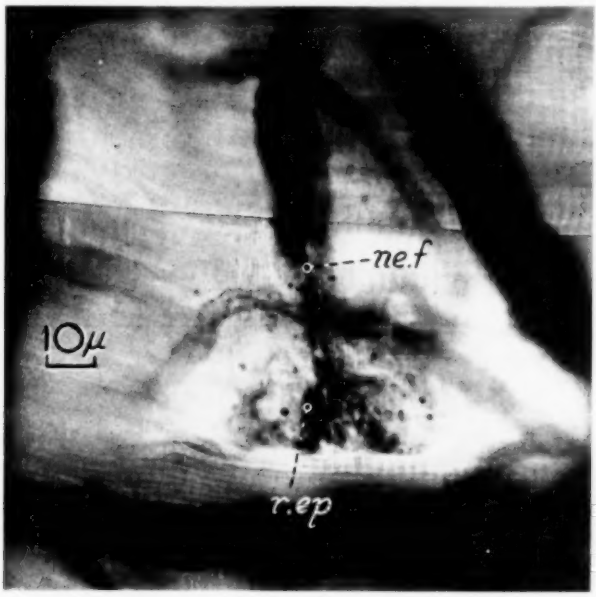

FIG. 11

Seven days after incomplete denervation. New fibre passing down swollen neurilemmal sheath to reinnervate end-plate. *ne.f.*—new fibre, *r.ep.*—reinnervated end-plate.

surviving end-plates and reinnervating neighbouring muscle fibres (Hoffman 1950) were not seen in these preparations. No signs of new fibre formation were seen in areas of the muscle containing only denervated nerve bundles. It has previously been recognised that the growth of new fibres occurs only in areas where degenerate and intact fibres are closely intermingled. The present investigation showed this important fact more clearly than those in which incomplete denervation is produced uniformly throughout the muscle by ramisection.

The following criteria were adopted in deciding which were new fibres and which were normal ones. 1) *Fibre size*: the contrast between the diameter of normal fibres approaching end-plates and new fibres appearing among them is marked. There is some variation of fibre size in normal muscles and therefore careful examination of the motor end-plate as well is important. 2) *Character of the motor end-plates*: there is a striking difference between the normal and the reinnervated motor end-plates. Gutmann and Young (1944), in a detailed

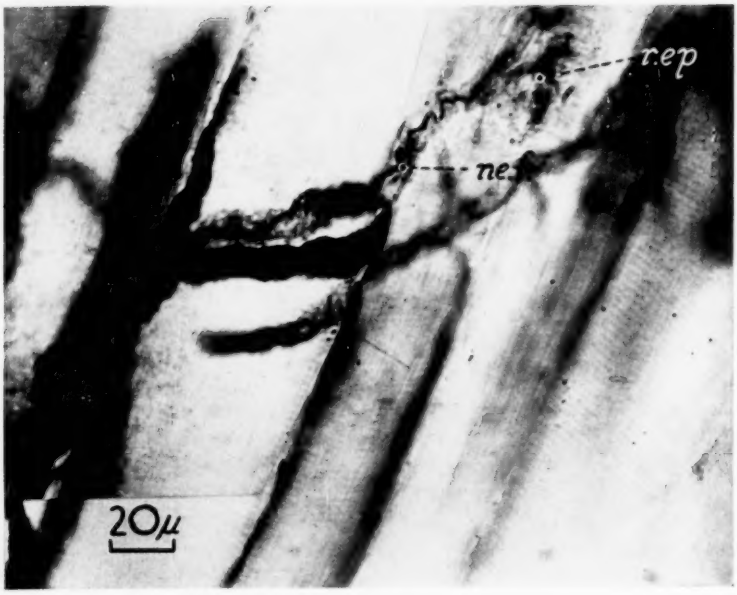

FIG. 12

Seven days after incomplete denervation. New fine fibre following old neurilemmal pathway to denervated end-plate. *ne.f*—new fibre, *r.ep*—reinnervated end-plate.

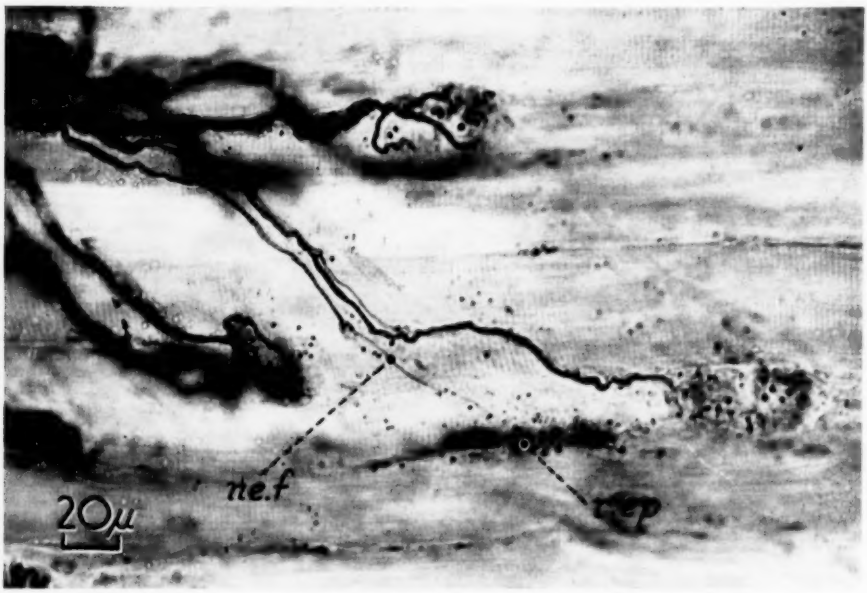

FIG. 13

Ten days after incomplete denervation. New fine fibre showing proximal thickening. *ne.f*—new fibre, *r.ep*—reinnervated end-plate.

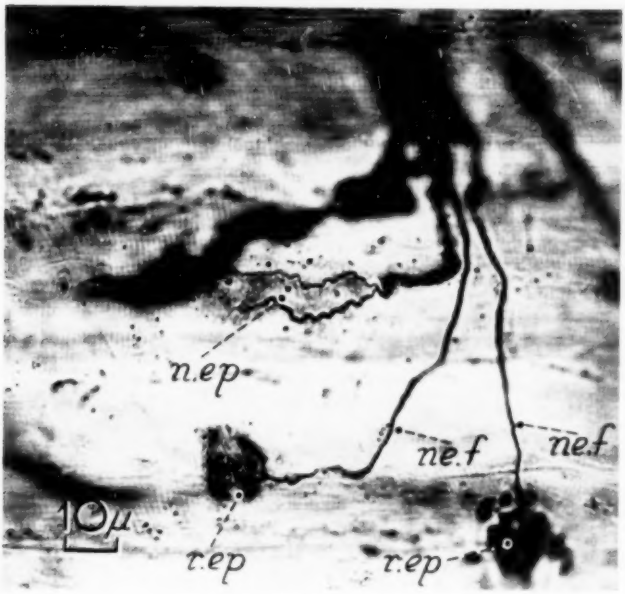

FIG. 14

Ten days after incomplete denervation. Spray of fibres showing one normal fibre and end-plate, and two new fine fibres ending in motor end-plates. *n.ep* = normal end-plate; *r.ep* = reinnervated end-plate; *ne.f* = new fibre.

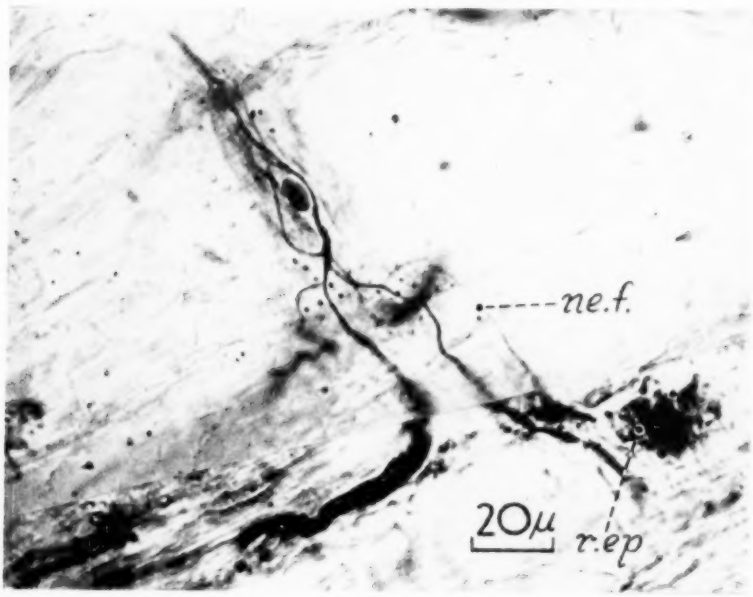

FIG. 15

Thirty days after incomplete denervation. New fine fibre branching off parent axon and entering empty end-plate. *ne.f* = new fibre; *r.ep* = reinnervated end-plate.

histological study of the myoneural junction in normal rabbit muscle, found the average number of terminal branches of the axon at the end-plate to be 5·8, with extremes of 2 and 11. These terminal branches, often referred to as "claws," are absent in the reinnervated end-plate (Fig. 9).

Using these criteria, it can be shown that production of new fibres is already evident four days after incomplete denervation of a muscle. During the succeeding weeks signs of reinnervation of the old end-plates are seen. It is important to decide whether all the new sprouts are formed in the days immediately after operation or whether more may be added later. When they are first formed the new fibres are very thin and presumably they increase in diameter later; the number of branches in the end-plates also increases. Unfortunately the rate at which these processes of maturation proceed is not known accurately. The number of fine fibres and simple end-plates seen is greatest during the first two weeks after operation,

FIG. 16

Forty days after incomplete denervation. Very fine fibre branching from parent axon and entering an empty end-plate. *n.f.*—new fibre; *r.e.p.*—reinnervated end-plate.

and seemingly declines thereafter. By the fourth week a few small fibres are still present, but none were seen later than the sixth week. These observations suggest that most if not all of the new sprouts are formed soon after the operation, and that they subsequently undergo growth and maturation.

DISCUSSION

Previous workers have examined muscles incompletely denervated by division of anterior primary rami. Their findings have been largely confirmed in this study in which incomplete denervation was accomplished by a peripheral method. This method results in a different pattern of denervation from that produced by ramisection, the chief difference being in the extent of the intermingling of intact and degenerate fibres, which occurs evenly throughout the whole muscle after ramisection. Sprouting of new fibres is therefore more extensive in muscles incompletely denervated by ramisection.

Growth of new fibres occurs only in areas where degenerated and intact fibres are closely

intermingled. So far this is the only observation that gives a clue to the stimulus required to promote the formation of new fibres. Now that it is established with certainty that collaterals can sprout from intact axons discovery of the stimulus required becomes of increasing importance. Since the growth of new fibres is delayed for three or four days after denervation, this may represent the time taken for the stimulus to develop. It is possible that striated muscle undergoes a rapid chemical change which provides the stimulus almost immediately, but that regeneration is prevented until the neurilemmal pathways are cleared of myelin. Degenerating myelin is cleared rapidly from the finer nerve bundles in partly denervated muscle. Examination of material three or four days after operation shows many empty neurilemmal tubes.

Work has been published suggesting the possibility that the stimulus is chemical. Van Harreveld (1947) studied the effects of an ether-extract of denervated muscle injected into the fascia surrounding the partly denervated sartorius muscle of the rabbit, and claimed that this caused more rapid recovery of the strength of contraction. Extract of normal muscle was ineffective. Hoffman (1950) injected extracts of denervated and normal rabbit muscle into incompletely denervated rat muscles. He found that both extracts produced blindly ending outgrowths from nerve fibres and end-plates.

Hoffman believed the stimulus to be the degenerating myelin present in the muscle after incomplete denervation, a view that is supported by the observation that regeneration occurs only when degenerated and intact fibres lie close together. He carried out a series of experiments two of which are of special interest. First, injection of ether-extract of white matter from ox brain caused a considerable increase in the number of outgrowths from intact axons, whereas extract of grey matter was ineffective. Secondly, ether-extract of yolk of egg was especially effective; in some regions of the muscles examined up to 50 per cent of the end-plates produced long blindly ending outgrowths. Moreover it is tempting to correlate the observation that degenerating myelin is rapidly cleared from the muscle with the finding that growth of new fibres is probably at its greatest soon after incomplete denervation.

So far there has been a large measure of agreement between independent workers using the rat and rabbit for their experimental work. When attempts are made to correlate this work with the work on primates and on poliomyelitis in man difficulties appear. Edds and Small (1951), working on the monkey, found that collateral regeneration of residual intramuscular axons occurred only to a limited degree after slight denervation and did not take place at all after extensive denervation. The concept of the nervous system as a static structure has undergone a radical change in recent years, and this growth of new fibres within partly denervated muscle is an excellent illustration of the lability of nervous tissue. It may be, however, that in higher animals this lability is diminished. Only further work can provide the answer to this.

Human muscle affected by poliomyelitis can continue to show an increase of power up to one year or more after the onset of the disease. This suggests that if sprouting of collaterals from intact axons is responsible for recovery, it must occur for at least a year after incomplete denervation. This does not accord with the observations in the rat and rabbit. Van Harreveld (1947) claimed that the power of contraction in the sartorius and quadriceps muscles of the rabbit continued to increase up to six months after incomplete denervation. This might be explained in two ways: sprouting of intact axons and hypertrophy of muscle fibres. Van Harreveld concluded that the first mechanism was the most important, but measurement of the "mean fibre surface" of the muscle fibres showed it to be greater on the side operated upon than on the other side, and he therefore considered hypertrophy of muscle fibres to be a definite but subsidiary factor in the recovery of the muscle. Weiss and Edds (1946) measured the greatest fibre size (diameter) in partly denervated muscles to decide whether hypertrophy played a part in recovery, but they failed to show any increase in size as compared with normal controls.

In assessing the possible importance of these mechanisms in the recovery of human muscles after poliomyelitis it must be remembered that the situation is complicated by the treatment given, for there is a possibility that regular exercises cause hypertrophy of the remaining muscle fibres in a paretic muscle.

The elucidation of the whole problem must await the discovery of the true stimulus to branching of intramuscular axons and whether this stimulus is capable of producing its effect in the partly paralysed primate muscle.

SUMMARY

1. The extensor digitorum longus of the rabbit was partly denervated by section of one of its two nerve branches and examined histologically for evidence of sprouting of new fibres.
2. Sections from material fixed two and three days after operation showed terminal bundles in which varying numbers of axons and motor end-plates have degenerated. This supports the concept that the motor unit is not confined to single groups of neighbouring muscle fibres, but innervates fibres scattered throughout the muscle.
3. New fine fibres branching from intact intramuscular axons to reinnervate denervated muscle fibres were observed as early as four days after operation.
4. Such new fibres were most numerous in the early weeks after operation and their numbers then declined. Two months after operation no small fibres or simple end-plates were seen.
5. No new fibres were seen in areas of the muscle containing only denervated nerve fibres. The new fibres were formed only under the stimulus of proximity to the degenerating ones.
6. The relationship of these findings to the mechanism of recovery of human muscle affected by poliomyelitis is discussed.

I am much indebted to Professor J. Z. Young and Dr J. T. Aitken for their help and encouragement in the preparation of this paper, and to Mr J. Armstrong and Miss R. Robbins for technical assistance.

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John Haddy James

John Haddy James was the first surgeon to introduce continuous traction, by weight and pulley, in the treatment of skeletal injuries—an innovation which has had an enduring importance in surgery.

He was born at Exeter on July 6, 1788, the son of a retired Bristol merchant. He was educated at Exeter Grammar School; afterwards he was apprenticed to Benjamin Johnson and later to Robert Patch, a well known surgeon to the Devon and Exeter Hospital upon whose surgical staff also was John Sheldon, F.R.S., sometime lecturer under William Hunter at the great Windmill Street School and first Professor of anatomy at the Surgeons' Company. On completing his apprenticeship James proceeded to St Bartholomew's Hospital in 1808 where he remained for four years, living for a year as house pupil to John Abernethy, whom he never ceased to admire. In 1811 he became a member of the Royal College of Surgeons, served a year as house surgeon at St Bartholomew's and in 1812 was gazetted Assistant Surgeon to the First Life Guards. He was present at the Battle of Waterloo; the Regimental Order Book of the following morning contains an entry that "Assistant Surgeon James was not in future to expose himself under fire as he had done on the previous day."

On July 2, 1815, James wrote to Benjamin Fuller of Hornsey saying: "I had only just time to despatch two or three short lines to you after the Battle of Waterloo. Till within these last two or three days, we have been marching incessantly and have had no time to write letters. We have been up every day at 3 or 4 o'clock, marching, halting and laying about in cornfields all day and the little time before sleep was employed in getting our dinner in the best manner we could. To add to this, for ten days we had no baggage up, no writing materials, nor any article of luxury.

"The campaign has been a very short one, but it was very severe for the few days it lasted, and I never in my life remember anything equal to the fatigue I experienced, partly owing to the want of provisions, for the whole business was so sudden, that we had no time to make any arrangement. You know as much of the battle as we do here, pretty nearly. After the commencement, it became necessary for the Medicals to retire under cover, for we were at first as much exposed to the enemy's fire, which was very severe, as any other description of people. Consequently, we saw very little of it thereafter. The defeat of the French was the most complete that ever took place, and yet their Army on the morning of the battle was probably nearly double the number of the British, and was superior to the joint armies when the Prussians came up. The arrival of the Prussians however, was very opportune. The French never in the least doubted in beating and destroying the Duke of Wellington's army, but as it turned out the other way, they suffered just as much as they expected to have made us suffer, for the ground where the battle was fought, whichever party was beat, was surely to be most grievously mauled. Nothing could be more unfavourable than the weather, during this business, but within these last few days, it has become most beautiful. The country we have marched through is most luxurious. I never saw anything equal to the corn in point of quantity or quality . . . I do not think we have passed over three acres of wasteland from Ostend to this place."

On July 15, 1815, James again wrote to Fuller from his regimental headquarters at Neuilly, near Paris, saying: "Those who were combatants on the 18th of June would, I believe, be very sorry ever to see such a day again. By all accounts it was far more severe than the British have at any former time witnessed . . . It happened that the Household Brigade was under the fire of the principal French battery. When we left the field to go to the houses in the rear, the men lay down by their horses. Nothing could be more decisive than the superiority of our heavy Cavalry over the French, notwithstanding their cuirasse which were impenetrable . . . The most essential piece of service done, by the 1st, was on the 17th, for then I verily believe they saved the rear of the Army. This is very certain,

that Lord Uxbridge (he then was) said on the ground 'You have retrieved the honour of the British Cavalry.' His own Regiment, the 7th and the 23rd had been routed by the Corps of cuirassers, which were subsequently cut to pieces. The 1st suffered nothing in comparison to the loss they inflicted on the enemy, and very little in proportion to other Regiments, the men say they care for nothing but the cannonading."

James remained with his regiment during the occupation; he was quartered with a French family at Clery near Orleans; he always spoke well of their kindness. He left the Army on his appointment as surgeon to the Devon and Exeter Hospital on June 11, 1816, in succession to Sydenham Peppin. He started practice at a house in the Cathedral Close and was most assiduous in his hospital duties, making careful and copious notes of his cases. He displayed great ingenuity in devising mechanical contrivances to aid in the treatment of injuries by way of special splints, syphons to aspirate exudate from wounds and abscesses, and a device to provide a constant water drip for inflamed surfaces. In 1818 he won the Jacksonian Prize of the Royal College of Surgeons for his essay on "Inflammation" which he afterwards expanded into a larger work entitled "On the General Principles and Treatment of Inflammation" which was published in 1821 and followed by a second edition in 1832.

James and his colleague Samuel Barnes felt that it was desirable to provide apprentices with scientific instruction over and above what a solitary general practitioner was able to provide. On January 7, 1819, they petitioned the Devon and Exeter Hospital in the following terms. "It being the intention of two of the surgeons of the Hospital, Mr Barnes and Mr James, to give an annual course of Anatomical Demonstrations to the medical pupils of the place on subjects procured from London for this purpose, they request, in concurrence with the other medical officers of the House, permission to employ the laboratory of the Hospital for this purpose." Permission was readily given. A pathological museum was formed of which James became curator and wrote the catalogue. For many years he and Barnes gave an annual course of lectures on anatomy. James attracted many pupils, some of whom were resident in his house and all were dressers at the hospital. In 1853 a museum was specially built, mainly on his suggestion; it was erected without expense to the hospital.

THE PROVINCIAL MEDICAL AND SURGICAL ASSOCIATION

By arranging hospital teaching for the apprentices the Exeter surgeons tended to unite them into a body, thus rendering them only partly subservient to their individual masters. It was an early attempt to provide in part a provincial as opposed to an exclusively metropolitan medical education. The same idea of improving the tone of provincial medicine and supplying a medium for discussion and diffusion of medical knowledge induced James and several others to meet Charles Hastings at the Worcester Infirmary in 1832 in order to found the Provincial Medical and Surgical Association. At the inaugural meeting James was elected member of the Council and a paper by him on the diagnosis of strangulated hernia, with some practical remarks on the operation, appeared in the first volume of the Association's Transactions. At the annual meeting held in Liverpool in 1839 he delivered the Retrospective Address in Surgery; in 1842 he was president of the two-day meeting at the Athenaeum in Exeter. James delivered a presidential address and gave clinical demonstrations in his wards at the Devon and Exeter Hospital. It is interesting to note that at the Association Dinner held in the New London Inn on August 4 one of the guests who replied eloquently to a toast was Archdeacon J. H. Pott—son of Percivall Pott—who was Canon and Chancellor of Exeter Cathedral.

At its annual meeting held in Birmingham in 1856 the Provincial Medical and Surgical Association, after some alteration in its code of laws, changed its name to that of the British Medical Association.

[We are grateful to the Governors of the Royal Devon and Exeter Hospital for permission to reproduce the portrait of John Haddy James.—EDITOR.]

John Haddy James
1788-1869

CONTINUOUS TRACTION BY WEIGHT AND PULLEY

In one section of his Retrospective Address in Surgery J. H. James dealt with the treatment of fractures. Speaking more especially of fractures of the femur he proceeded to describe a method of treatment he had carried out for several years.

"M. Josse, of Amiens, has proposed a plan of treating these fractures by permanent extension, and in few words it may be stated to consist in fixing the foot to the bottom of the bed, which is raised, so that the weight of the head and trunk being depending, produce a constant extension along the plane. To this some inconveniences must attach, although they are not much regarded by the proposer. I may perhaps be permitted to say that nearly two years before M. Josse's work was put into my hands, I had adopted the same principle, but carried it into effect in a different, possibly it may be thought a preferable mode, viz., by fixing the superior part of the body to the head of the bed, which is raised, and making

PLATE I.

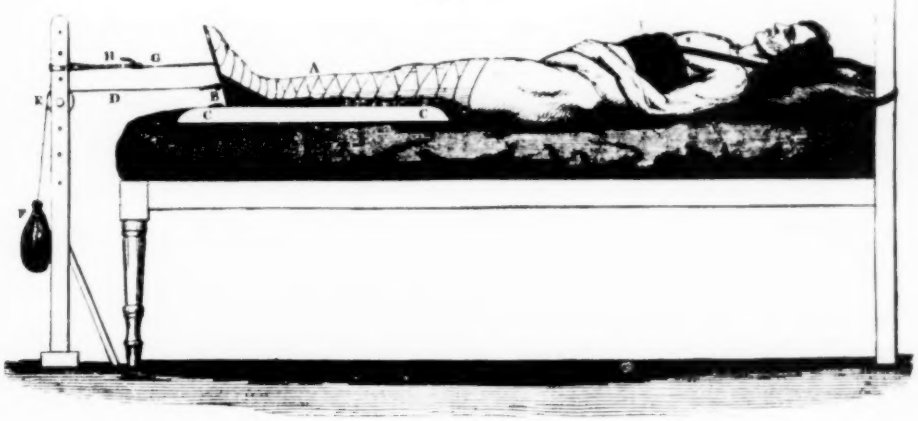

FIG. 1

Plate I in James's "Retrospective Address in Surgery". The legend ran as follows. A. The leg bandaged and guarded, laid upon, and secured to the hollow splint, with foot-piece. B. This hollow splint resting upon the castors, mortised into the wooden plane C, upon which it can easily slide. D. A cord affixed to the foot-piece, and passing over the pulley E, is extended by any requisite amount of weight placed in the bag F. G. A strap with a buckle, H, by which when the limb is fully extended, the tendency to retract under the influence of the muscle is greatly contracted (see for counteracted). I. A rib bandage fixed to the upper part of the thorax, and secured to the posts of the head of the bed by ligatures extending from it; large soft towels should be placed along the arm-pits to avoid galling. The extension may be rendered more powerful by placing two blocks under the posts at the head of the bed so as to give it an inclination to the foot. The splint which receives the leg should be well hollowed at the heel, and that carefully guarded. The line of traction should be rather a little upwards, otherwise the heel is pressed down.

extension on the limb by means of a weight fixed to the leg, properly guarded, and acting over a pulley, assisted also by a very simple apparatus, which it would occupy too much time to describe here, but of which I beg to offer a representation to your notice (Figs. 1 and 2). The result of this plan during several years has been very satisfactory, inasmuch as the limbs have been restored to a very perfect condition, and the patients have complained very little of the treatment when due care has been taken. The principal advantage of this mode of treatment appears to be this,—that for any apparatus to succeed which has not the power of accommodating itself (and such are those commonly employed), it is necessary, not only that it should be perfect in its nature, but that the ligatures by which it is applied should not yield; but this must of course vary according to the state of the tackle, and the skill and attention with which it is adjusted, as well as the patience of the person treated, whereas, in the plan proposed, the apparatus will accommodate itself, and if from any movement the

limb should be for a moment shortened (which however is especially guarded against), the steady but gentle force in operation will restore it to its proper length.

"Since the foregoing passages were read at the meeting, in a communication I had the pleasure of having with Mr Syme, at Edinburgh, he informed me that Hildanus had used the weights and pulley, and on reference I found that this was the case, so that neither M. Josse nor myself are entitled to the credit of this mode of treatment, if really preferable to others; but at all events, in recommending it once more to public attention, there is the satisfaction of knowing that this may be done on higher authority than we can pretend to boast of, and if the "*multa renascentur*" applies against our claims to originality in this respect, we may,

PLATE II.

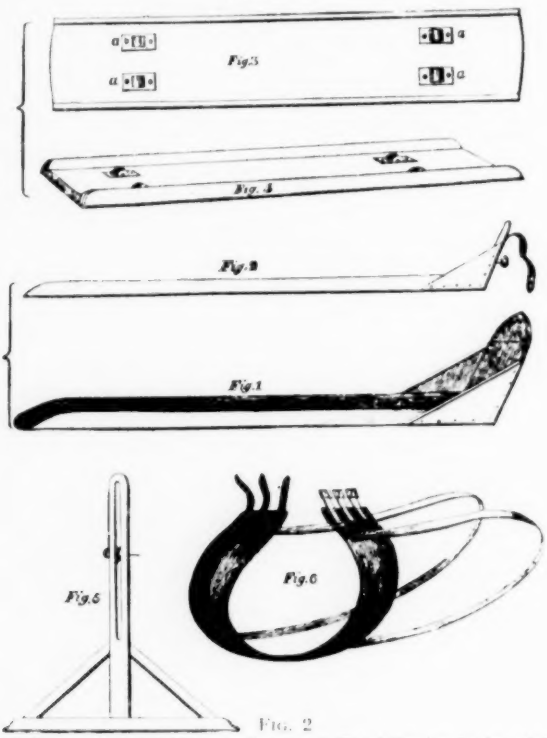

FIG. 2

Plate II from James's "Retrospective Address in Surgery." The following is the original legend. 1. A side view of a hollowed splint on which the leg rests, being previously well guarded, and to which it is secured with bandages. 2. Shows the ring at the foot-piece, to which the cord and strap are affixed. 3. Horizontal representation of the plane of wood on which the preceding rests, and on which it can be readily moved as it rests on the castors *a, a, a, a*. 4. A side view of the same. 5. The stanchion fixed into the floor at the foot of the bed, and containing the pulley over which the cord passes. 6. A rib bandage with two ligatures attached which fix the thorax to the two upper posts of the bed.

nevertheless, have a right to hope that this old plan may be revived with advantage, as well as that of the immoveable apparatus (to be presently mentioned), the offspring of still greater antiquity.

"But although the method itself be not new, perhaps it may still be thought that the manner in which it is adapted to the accident is more suitable than that used by Hildanus or (in a more imperfect sort) by Paré. It is not improbable that the rather coarse mode in which the former great surgeon employed it may have proved the cause of its entire and long abandonment. Fixing the upper part of the body by what he calls a remora, he simply applied a vinculum with cords and weights attached, round the thigh just above the knees,

which must have occasioned an almost entire stoppage of the circulation if any weight were used adequate to the occasion, and no means of supporting the vessels below by a bandage seem to have been used. With regard also to the principles on which the superiority, if any, of the proposed plan to mere fixed extension depends, and which has not, as far as I am aware, been mooted by any one, the observations here offered may perhaps be deserving of some attention."

Hugh Owen Thomas maintained that Syme was mistaken in asserting that Hildanus had practised the method of continuous weight traction and declared that " J. H. James's method of continuous extension was original, and I do not believe that he had any suggestion from the published opinions of his predecessors." Fabricius Hildanus, regarded as the father of German surgery, published a great medical work in 1646, in which is described and depicted a girdle or strap bearing two metal hooks placed diametrically opposite to each other. The ends of a strong rope were fastened to the hooks and from its middle a container, enclosing two pulley blocks, was suspended (*laqueo annectendum est Instrumentum trochleatum*). Some surgeons mistook the container for a stone and referred to it as the " Jack Stone of Hildanus." The appliance was first used for the reduction of dislocations but later it was also employed for the rapid reduction of fractures. In the case of a dislocated hip the girdle was buckled tightly above the knee; the container with its contents having been removed, the surgeon pulled strenuously on the rope in the hope of reducing the dislocation. If he failed he had recourse to the mechanical advantage of the pulley blocks, fixing one to a pillar or wall and the other to the girdle rope. The pulley rope fixed to one of the blocks passed in a continuous coil around the two sets of pulleys, leaving a free end upon which the surgeon pulled. In his narrative Hildanus stated that similar pulley blocks were used by Ambroise Paré for the reduction of dislocations. On referring to Paré's great surgical work it will be seen that the two pulley blocks and containers are exactly the same as those depicted by Hildanus and there is an illustration of the apparatus in use in the reduction of a dislocation of the hip.

Neither the contrivance of Hildanus nor that of Paré was intended for anything but short rapid traction. They are ill adapted for the prolonged traction of fractures, nor is there visible a free single pulley in any of the illustrations. All the evidence available confirms the view expressed by Hugh Owen Thomas that J. H. James's method of continuous extension was original. Indeed if the instrument of Hildanus was the only one that could be thought of as an earlier rival to the invention of James it is a reasonable inference that before 1839 there was no such thing as long continued traction by weight and pulley in the treatment of injuries. A glance at the illustration of the traction apparatus of James, with his description, produces a vision of completeness, even modernity. There is no feeling of antiquarianism; even the castors are intriguing. Skin traction by strapping or skeletal traction by pin are progressive variations of James's theme.

In 1843 when the Royal College of Surgeons was reconstituted under its new charter James was elected one of the original Fellows. Furthermore he presided at the annual dinner of the Fellows held on July 3, 1851, at Lovegrove's Brunswick Hotel, Blackwall. In 1856 he retired from the active staff of the Devon and Exeter Hospital and was appointed a consulting surgeon and a governor of the hospital.

James was a good anatomist and pathologist; a careful though not a dexterous operator and on occasion bold. He had a gift for invention; his wards had many original devices designed to promote healing or restoration of function in his patients, about whose welfare he was very solicitous. He made many contributions to surgical literature; besides those already mentioned two others should be noted, one entitled " Some Contributions to the Pathology of Fibrous Tumours," in two articles in the *Lancet* (1868), the other " On Ligature of the External Iliac Artery in a case of Double Aneurism " (1844).

James did not allow the duties of his profession to absorb all his time. His interest in the community of Exeter led to his becoming a member of its Corporation in 1820, Sheriff

in 1826 and Mayor in 1828. In appearance he was of middle height, well built, his features handsome, blue-eyed and fresh coloured. In early professional life he went about on horseback clothed after the fashion of the period: he wore a blue dress coat with brass buttons, buff waistcoat, high collar and full neck-cloth, breeches and top boots. He was energetic, determined, tenacious of his opinions, and thoroughly honest; on social occasions he was kind, joyous and had a nice turn of wit.

He married Miss Elizabeth Wittal, by whom he had nine children; after her death he married Miss Harriet Hills, without family. One of his sons, William Wittal James, became surgeon to the Devon and Exeter Hospital. For many years J. H. James had lived at the lower corner house of Chichester Place, East Southernhay; here he died on March 17, 1869. Early in life he infected himself at an autopsy and became dangerously ill on his way to London; he was treated by Abernethy in his own house. Afterwards James enjoyed robust health until his last five years when he developed glaucoma and optic neuritis which ended in blindness.

John Haddy James had a considerable reputation as a West Country surgeon during the first half of the nineteenth century. He modelled himself on Abernethy of whom he was both pupil and friend. He took a prominent part in raising the standard of extra-metropolitan surgery and was a powerful supporter of the movement to bring all members of the profession together into an association for mutual instruction and protection. He was a good anatomist and a good pathologist but he had in addition an inventive mind to which he gave full rein at his hospital in Exeter. One of his resourceful inventions was directed towards providing continuous yet tolerable traction in the treatment of skeletal injuries. This he achieved by weight and pulley. The apparatus he described was so simple in design that it was capable of use in any country cottage. The need for continuous traction had long been felt but James's contribution towards its provision was scarcely appreciated. Weight and pulley traction is now a commonplace procedure in surgery but he who had the heart and mind to introduce it deserves to be remembered.

ARTHUR ROCYN JONES.

I wish to express my thanks to Miss Betty Farrington of Exmouth for her kindness in allowing me the use of letters and papers of her distinguished ancestor. I also gratefully acknowledge the help of Mr Norman Capener.

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HISTORICAL SURGICAL INSTRUMENTS IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND (3)

W. E. Thompson, London, England

Clerk of the Museum, Royal College of Surgeons of England

Preserved in a wooden case covered with sharkskin is an example of a spring cataract knife devised by Guérin of Lyons in 1785, which represents his second model (Fig. 21). The knife is attached by its stem to a spring in the brass case, and can be set for action by depressing the thumb-lever and pushing it to the right. The ring is then applied to the eye, the thumb presses the lever holding the stem, and the knife moves swiftly across the lower part of the ring, making a corneal flap. By turning the thumb-screw at the base of the case to the right or left, the knife is drawn nearer to, or away from, the ring. Guérin claimed that it enabled the operator to use it on the right as well as on the left eye. P. Lassus illustrated and described this instrument in his *Médecine opératoire* (1795). It was presented by Sir Anthony Carlisle in 1823.

Fig. 21
Cataract knife devised by Guérin of Lyons in 1785.

"The favourite cataract knife of Friederic von Jaeger (1784–1871) of Vienna, the exact model of that made by his father-in-law the celebrated Beer" (1763–1821). This note by the donor, Sir William White Cooper, accompanied the Beer's cataract knife seen in Figure 22. Other instruments formerly belonging to von Jaegar are a double hook, strabismus hook, and Charrière's double clip for steadying the eye (Fig. 22).

A box containing four cataract knives (Fig. 23) was presented by Mr Jabez Hogg (1817–1899), in 1873, as "a case of cataract instruments presented by Professor Beer to Mr G. J. Guthrie" (1785–1856), president of the College in 1833. Three of the knives are Beer's and the fourth Desmarres's secondary cataract knife, and all are marked with the letter "G," Guthrie's initial. The secondary cataract knife is stamped "Savigny & Co." and one of the Beer knives shows the letters "gny," the rest of the name being effaced. The late Mr C. J. S. Thompson, Honorary Curator of the Historical Section, believed that Savigny had a branch at Vienna, or that Beer had knives made in London. G. J. Guthrie's guarded cataract knife, used by the inventor (Fig. 23), is illustrated in the second edition of his *Lectures on the Operative Surgery of the Eye* (1827), but it is not identical in pattern. The cutting blade is made of steel and the guard of silver. Another knife was "a favourite knife of Frederick Tyrrell's." F. Tyrrell (1793–1843) in his *A Practical Work on the Diseases of the Eye* (1840) described this knife as "a modification of that formerly used by Professor Beer, at Vienna." Tyrrell was an articled pupil to Sir Astley Cooper and his nephew by marriage.

A delicately made and complicated instrument is Grossheim-Geiger's raphiankistron for

FIG. 22

Four instruments used by Friederic von Jaeger, of Vienna—Beer's cataract knife, double hook, strabismus hook, and Charrière's double clip.

FIG. 23

Left—Three Beer's cataract knives and Desmarre's secondary cataract knife. *Third from right*—G. T. Guthrie's guarded cataract knife. *Second from right*—F. Tyrrell's modification of Beer's cataract knife. *Right*—Grossheim-Geiger's raphiankistron for coredialysis.

coredialysis. The lance-shaped knife is mounted on a spring, worked by a button moving along a slot in the brass tube. When the button is pushed forward, the knife is protruded until the lance-head lies between the two guards which press into the depression on each of its sides, and so the cornea is incised. On pressing the spring-levers, the knife flies back. Then the guards can be used to grasp the iris, and to detach from its ciliary border as much of it as is desired by the operator. This instrument was described at great length by E. Grossheim in 1826. When the author was travelling with Prince William of Prussia (afterwards

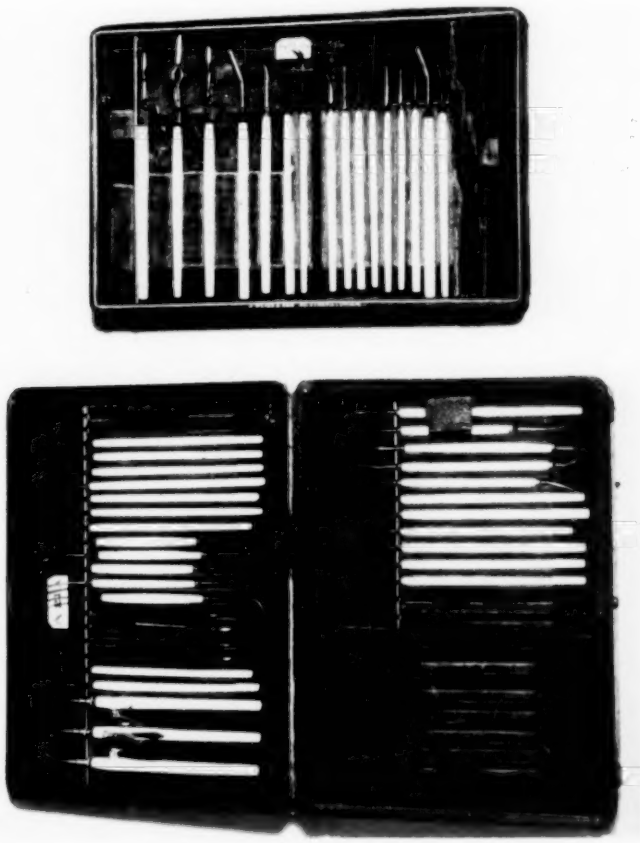

FIG. 24

Two cases of ophthalmic instruments formerly belonging to Sir William Bowman, many of which are of his own invention.

the German Emperor, William I) he designed with the aid "of a most ingenious German instrument-maker, Geiger by name," this instrument, and Lerche, with other Prussian ophthalmic surgeons, after employing it, all agreed with Grossheim that it was admirably adapted for the making of an artificial pupil. In conclusion, Grossheim dwelt upon its special advantages for iridodialysis (coredialysis). The example shown in Figure 23 was the property of William Long, F.R.S., and was given to the Museum by his widow in 1818; hence it was made many years before Grossheim published his memoir. This instrument would seem to have been made originally by Geiger, who was probably the sole designer of the raphiankistron, Grossheim effecting some modification in later years.

FIG. 25
Dr H. A. Lediard's railway colour testing instrument.

There are two cases of ophthalmic instruments which belonged to, and were used by, Sir William Bowman, Bart., F.R.C.S. (1816–1892) (Fig. 24). The larger one was presented by his grandson, the Rev. Sir Paget M. Bowman, Bart., in 1930; it contains thirty-three instruments, two probes, a small curved needle and some black silk. The other was presented by Mr Thomas H. Court in 1931, and contains sixteen instruments. In both sets there are instruments of Sir William Bowman's own design.

Lediard's railway colour testing instrument is shown in Figure 25. It is "a simple instrument designed for the use of surgeons who are required to test the colour vision of men and lads taken for employment on the railway. The colours given are blue, yellow (i.e., the railway signal white light), green, mauve, and red. The test is used by holding the instrument against the light, and turning the disk round, so that the person examined sees the colours in much the same way as he would were he looking at signals" (Lediard 1889). Dr Lediard was the inventor of this instrument, and presented this example, modified from that described in the *Lancet*, to the Museum in 1919.

In a leather-covered case is preserved the original otoscope invented by Dr John Brunton (1836–1899) (Fig. 26). It is the instrument that Dr Brunton exhibited before the Medical Society of London in 1862, and is recorded in the minutes of the Clinical Meeting held on December 8, 1862 as follows: "Dr Brunton practically showed a new auriscope of his own invention and described the nature of its construction." A description of the instrument was reported in the *Lancet* by Brunton in 1865. It was presented by Dr John Brunton, the son of the inventor, in 1931.

The ivory ear trumpet (Fig. 27) was specially made for and used by Admiral Sir John Borlase Warren, Bart. (1753–1822). It is an elegant instrument consisting of a trumpet, an

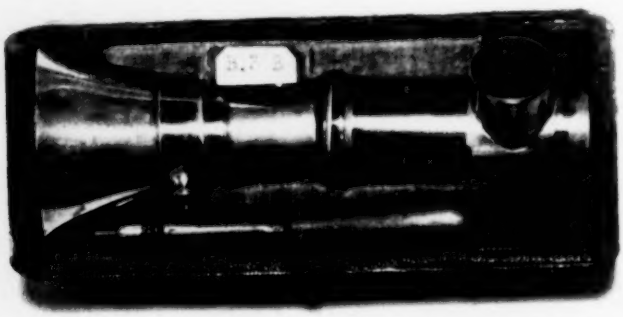

FIG. 26
The original otoscope invented by Dr John Brunton in 1862.

carpiece, and a series of cylinders forming a tube. The *Dictionary of National Biography* (1899) contains an account of Sir John Borlase Warren's life. The instrument was presented by the great-grandson of the Admiral in 1914.

A heavy brass ear syringe made towards the end of the eighteenth century, and before the finger-rings were added to the upper cap of the cylinder and on each side of the piston, is illustrated in Figure 28. There are also two examples of india-rubber ear syringes of the

FIG. 27
Ivory ear trumpet made for and used by Admiral Sir John Borlase Warren (1753-1822)

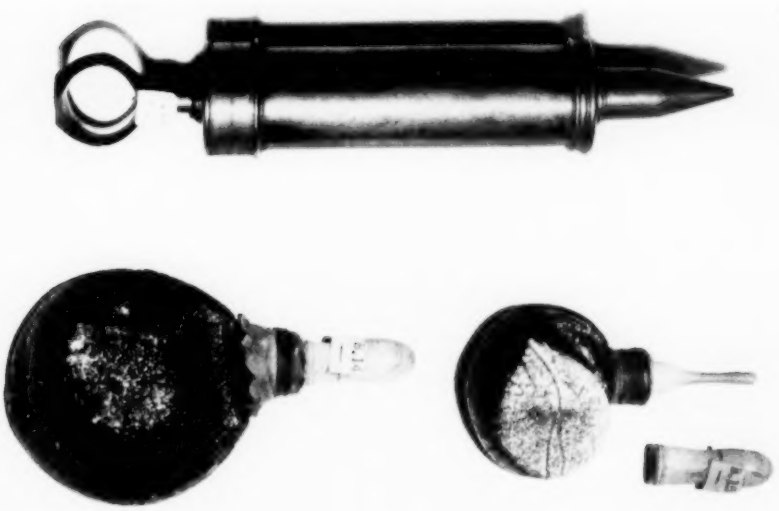

FIG. 28
Above.—Brass ear syringe, late eighteenth century. *Below*.—Two india-rubber ear syringes, *circa* 1800.

earliest type (Fig. 28) which were in use in England about 1800. Savigny in his *Instruments* (1798) devoted Plate XVIII to "Elastic Bottles," and adds the following: "It is not my intention, nor does it fall within my ability, to enter into the natural history of this wonderful production. I shall only say that, in respect to its mechanical properties, surgery has received few more important acquisitions."

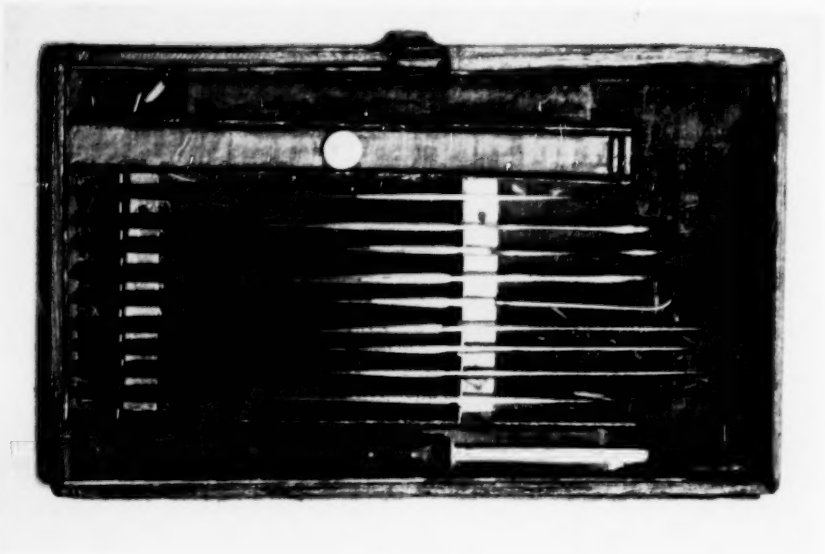

FIG. 29
Case of cleft palate instruments once the property of the inventor, Francis Mason.

A case of cleft palate instruments (Fig. 29) was once the property of the inventor, Francis Mason, F.R.C.S. (1837–1886). The case contains four Mason's cleft palate knives, two Ferguson's cleft palate knives, a small scalpel, three cleft palate suture needles and hempen twine sutures. These instruments were used by their designer in his private practice, and were purchased by the donor, Sir George Makins, Bart., after his death. A silver plate on the lid of the case is engraved " Fcis. Mason " in italics. Reference to the instruments was made in a paper " On Cleft Palate," by Francis Mason, in 1876.

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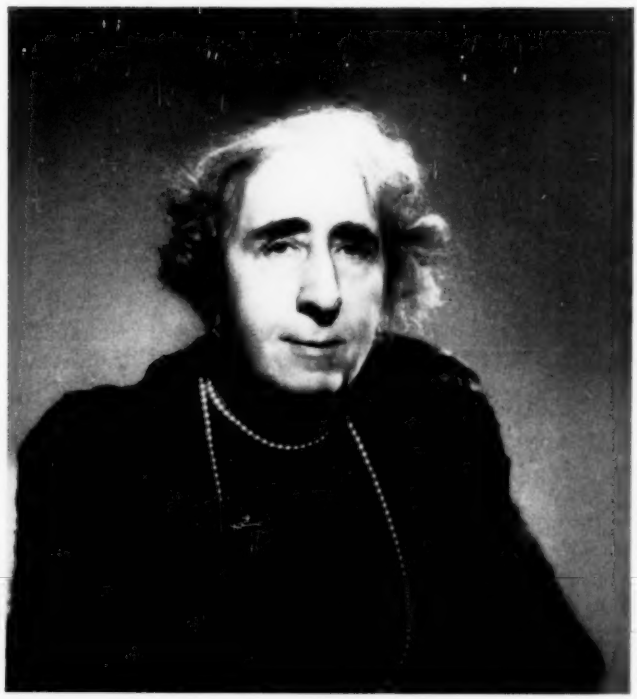


DAME GEORGIANA BULLER, R.R.C., D.B.E.

1884-1953

With the passing of Dame Georgiana the cause of rehabilitation has, throughout the world, lost a champion of dynamic personality and insuperable courage. Her character was of great complexity with its mixture of single-minded determination, brilliant intellect and simple kindness. Her youth was grounded in the social circle of a county family and the atmosphere of military discipline, nobility and integrity given by her ancestry. Her own life became a grand essay in rehabilitation.

She was the only child of General Sir Redvers Buller, V.C., G.C.B., G.C.M.G., whose fame as a soldier in South Africa was equalled by the affection with which he was held by those who fought with him and by their families in Devon. Her mother was Lady Audrey Buller, the youngest daughter of Rear-Admiral the fourth Marquess Townshend. Georgiana Buller was greatly influenced by her father, for whom in youth she acted as companion and secretary. The impressions of these years greatly affected her future interests. Before the Great War of 1914-18 she became prominent in the county organisation in Devon of the British Red Cross Society and at the same time developed her interest in people and in the countryside, where she was a first-class rider to foxhounds. In 1914 she seriously injured her spine in a hunting accident and before fully convalescent she insisted on getting up and proceeding to establish, soon after the outbreak of war, the Exeter V.A.D. Hospital. In 1916,

in the reorganisation of War Hospitals which proved necessary, that hospital, which had grown to 1,500 beds, was taken over by the War Office and soon had forty-eight auxiliary hospitals affiliated to it. As reported in *The Times*, " The whole complex organisation was administered with remarkable efficiency by Miss Buller until demobilisation in 1920 and she was the only woman to hold such a post in that war."

Since then we have become more familiar with the idea of women in high administrative positions. At that time, however, Dame Georgiana was a pioneer not by any feminist agitation but by sheer ability—an ability which was backed by complete self-confidence. It was perhaps not unnatural that she aroused the fiercest antagonisms from lesser minds, and from people hidebound by orthodox military procedure, and from those whose interests were not strictly related to the country's need of succouring the maimed and returning the recoverable to fitness in the shortest possible time. Her approach to the hospital problems of that war was original and with a strong personality she got her way against prejudiced obstruction. Her co-workers and juniors found her easy to work with because she was definite, knew what she wanted and was unusually fair and reasonable. She set a high standard and expected the same of others. The incompetent fared badly. She was a master of procedure and knew Army Council Instructions minutely. With dialectic and forensic ability she used all means to complete her purpose. Her greatness was recognised in 1920 when she received the Royal Red Cross and was created D.B.E.

The experiences of 1914 to 1920 exhausted her physically and psychologically. Her old spinal injury became troublesome and, not unlike Florence Nightingale, she collapsed and became herself a semi-invalid. From a state of lethargy she was aroused a year or two later by her farseeing medical advisor, the late Dr Henry Andrew, aided and abetted by one of her former surgical colleagues in the War Hospital, the late Brennan Dyball, F.R.C.S., who himself was one of the general surgical pioneers of orthopaedics in the South-West of England. In the partnership that followed Dame Georgiana truly rehabilitated herself. In a campaign in which they had assistance and encouragement from Robert Jones and Rowley Bristow money was raised for what was expected to be a " white elephant." Those who thought they knew said, of course, that there were no cripples in beautiful Devon. Eventually in 1927 the Princess Elizabeth Orthopaedic Hospital at Exeter was opened by the Duke and Duchess of York (as they then were) and named after the young Princess who now is our Queen.

It is interesting to look back at the first report of the Hospital's work which Dame Georgiana wrote. " Although it was not a pioneer, it can claim," she said, " the distinction of representing the only attempt yet made to co-ordinate within the framework of a single comprehensive organisation every form of activity bearing on the cripples' welfare." She did not then use the word rehabilitation but she recognised that medical and surgical treatment was not enough and that there must also be a welfare service and vocational training with it.

During these years it was natural that Dame Georgiana should play a prominent part in the work of the Central Council for the Care of Cripples and she was for some time vice-chairman of its executive committee. Believing that the medical and surgical aspects of rehabilitation were becoming adequately developed largely through legislative action she devoted her mind more and more to the problems of training and resettlement. In 1935 she gave up her more active interest in orthopaedics and established the two colleges for training and rehabilitation at Leatherhead (the Queen Elizabeth College) and at Exeter (St Loyes College). Established as regional centres, both became national in their scope and, though administered by voluntary bodies, carried out this work with the closest co-operation of the Ministry of Labour. This perhaps was not unconnected with the friendly help of the late Ernest Bevin who remembered that in his youth he had gathered apples from her father's orchards.

In the last fifteen years of her life, while maintaining her great interest in the national problems of rehabilitation (she was largely instrumental in establishing the British Council

for Rehabilitation), Dame Georgiana's particular daily concern was the College at Exeter and she carried to a large extent its administrative responsibility. In this she showed both her strength and weakness: the latter in that she took charge of matters which should have been left to efficient chiefs. Her strength expressed itself overwhelmingly in two ways. Firstly her ability to control official bodies and individuals by her almost hypnotic power of persuasion and the clarity of her logic. Secondly by her deep humanity. She had an uncanny gift for understanding the thoughts and feelings of the lowliest of trainees, and to speak in the simple language each could understand. If they failed to make the grade it was not through lack of encouragement and practical sympathy from her. She was able to get beyond the façade of reserve and inferiority. One dominant idea was found in all her work: it was "completeness." She did not ask that her trainees should be brought to a stage where they could work only with charitable help or subsidy. The ideal to be pursued was complete independence: training for work which the community wanted for the work's sake, and was prepared properly to reward, without any tag of commiseration. She never permitted anyone to believe that the individual was not capable of achieving this physical rehabilitation and the spiritual completion which it made possible.

A few remarks should be given upon a scheme which she instituted in 1947 for "preparatory training." She recognised the special needs of young men and women compelled by disease to spend many months in long-stay hospitals—for instance, sanatoria as well as orthopaedic hospitals. Occupational therapy, though pleasant enough as a diversion, often lacked contact with the patient's previous experience and future needs. Her scheme was to arrange courses of study for those who were capable of it, so that subjects from Arabic, book-keeping and chemistry to zoology could be taken and thus engage profitably the months as they passed. The first of these preparatory training schemes was established at Exeter: it covered the whole South-Western region and even beyond. The cause of the spastic child was another particular interest; by her faith she had proved against all advice what many could do at her colleges. She was impressed by the physical and educational neglect which so many of them showed on arriving for training. Her inspiration was in no small way responsible for the establishemnt in 1948, by the Dame Hannah Rogers Trust, of their School at Ivybridge.

Whatever Dame Georgiana put her hand to, she did superlatively well. She was a Justice of the Peace and she had a keen interest in music, drama and the arts. As recently as 1936 she acted in a charity performance and she did it with complete mastery and great humour—strangely enough it was as a witch. She was keen on gardens and had a great love of children. Her relatives saw this side of her at its best; she was charming with them. Equally was she with hospital children. Her rather stern face would light up with an unexpected happiness and interest. She forgot herself by getting into the lives and understanding of each.

Dame Georgiana was a most able chairman of committees; orderly, coldly logical and quick in repartee. She was patient and kindly when working with those she liked or respected but ruthlessly direct and impatient with those who by foolishness, thoughtlessness, incompetence or obstinacy stood in her way. Many feared her but none despised her. People who with her "agreed to differ," remained her warm admirers and friends for she was indeed magnanimous.

Dame Georgiana would have been less than human had she no frailties but her worth towered above these in the true genius she possessed and in her almost regal dignity and understanding.

N. C.

VALENTINE HERBERT ELLIS

1901-1953

On the morning of Tuesday, September 15, 1953, V. H. Ellis had just seen the last patient at his fracture clinic at St Mary's Hospital when he suddenly collapsed and died. He was only fifty-two; he had known for some months past that he was seriously unfit and it was characteristic of him to go on working until he dropped.

Valentine Herbert Ellis was born in India on February 24, 1901, and was the son of Major-General Philip Ellis of the Army Medical Service. He was educated at Wellington, Clare College, Cambridge, and St George's Hospital. He graduated in 1925, became a Fellow of the Royal College of Surgeons of England in 1928 and at about that time turned his attention to orthopaedics. He became a surgical registrar at the Royal National Orthopaedic Hospital, was appointed Assistant Surgeon in 1931 and served the hospital faithfully until he died. In the following year Ellis became the first orthopaedic surgeon at St Mary's Hospital. No happier choice could have been made. He was no narrow-minded specialist, and it was fitting that the first and moving tribute paid to his memory came from his friend and colleague, George Pickering, the Professor of Medicine. It was the breadth of his interests that made Ellis such a remarkable person. Few orthopaedic surgeons nowadays can claim to have a proper knowledge of every aspect of their work, but Ellis could and this invested his opinions with unusual value. He was very well read and by means of other appointments, as at Lord Mayor Treloar's Hospital, Alton, and at the Heatherwood Hospital, Ascot, he accumulated a vast and varied experience. His versatility was reflected in the papers he wrote; they were not numerous, just over twenty, but each dealt with some important aspect of a different problem. He was never repetitious. This all-round competence in orthopaedics was strengthened by his knowledge of medicine in general, of medical administration, of public affairs and by his ability to assess the characters of other men. Ellis was above all

a wise man and he possessed the urbanity and detachment that would have made him a good judge or colonial governor. Yet these qualities were not such as to attract the attention of the crowd or even of the profession at large. He was not a brilliant innovator or a popular orator and his talents were concealed by a natural reserve that could be a little forbidding. His comments on men and affairs were terse and sometimes epigrammatic. Those who knew him well instinctively sought his opinion, and even his verdict, not only on clinical problems but on difficult matters of administration. It was natural that he found himself on the governing bodies of both of his teaching hospitals and he was chairman of the Medical Committee of the Royal National Orthopaedic Hospital and of the Academic Board of the Institute of Orthopaedics. His colleagues in the Institute had particular reason to be grateful to him; a young postgraduate school is very vulnerable to the influence of reaction on the one hand and unbalanced enthusiasm on the other. Ellis disliked both, and he used the great weight of his authority to keep the course steady and the pace even. When he spoke as treasurer of the British Orthopaedic Association he was no tame book-keeper but a maker of policy. He would have been one of the Association's greatest presidents. He had already served with distinction as president of the Orthopaedic Section of the Royal Society of Medicine.

Ellis was wholly free from self-importance and it seems never to have occurred to him to seek his own advancement; his thoughts were for the benefit of his patients and of any organisation with which he was connected. His private life was distinguished by simplicity and contentment. He was devoted to his wife and two children and there was a quiet elegance about their charming house in a pleasant backwater of Paddington. It was furnished with perfect taste; there were even tapestries that Ellis himself had worked in his odd moments of leisure. The garden was his particular delight and he would invite the visitor to inspect his fifteen varieties of lily, though his descriptions of their characteristics were always punctuated by powerful imprecations against his only enemies—the stray cats of Paddington.

Three of his activities as a surgeon are particularly noteworthy. In 1937 he and B. H. Burns, his closest friend since they were undergraduates together, wrote *Recent Advances in Orthopaedic Surgery*, an exceptionally valuable book that should have gone into further editions; it revealed the breadth of the authors' interests. During the war Ellis was posted to the emergency hospital at Park Prewett in Hampshire where he worked with unremitting devotion. In 1945 he and Innes published a short but significant paper on "Battle Casualties treated by Penicillin," based on a study of no less than 15,000 cases. A quotation from this paper reveals his sanity at a time when there was much uncritical enthusiasm: "Penicillin has made no difference to the paramount importance of early and adequate surgery; it has, in addition, produced new difficulties in that the effect of penicillin on contaminated wounds obscures the extent of the infection of the tissues, and makes it difficult to judge how radical surgery should be." Lastly there was Ellis's growing interest in disorders of the shoulder joint; he studied these puzzling conditions with patience and care, his employment of arthrography proved of immense value in the elucidation of injuries of the rotator cuff, and his published papers give some indication of what might have been expected from him, had he lived longer.

In his intellectual stature Ellis belonged to an earlier generation, to that great group of men who were the friends and disciples of Robert Jones. This is why his untimely death is so grievous a blow.

H. J. S.

EWEN ALISTAIR JACK

1909-1953

Orthopaedic surgery, and the Edinburgh School of Orthopaedic Surgery in particular, have suffered a grievous loss in the tragic death of Ewen Alistair Jack at the young age of forty-four years. He was born on June 31, 1909, at Hartlepool, where his father was in general practice. He was educated at Fettes College and studied medicine at Edinburgh University. At the University he captained the rugby fifteen before he graduated M.B., Ch.B. in 1932. After house appointments in Edinburgh and Leicester he became a Fellow of the Royal College of Surgeons of Edinburgh in 1935. Before returning to Edinburgh as Clinical Tutor in Surgery at the Royal Infirmary, he spent some time in postgraduate study in London. He had thus equipped himself with a sound training in general surgery before, with the outbreak of war in 1939, he joined the Royal Army Medical Corps. His career in the Army was a distinguished one: he served with the British Expeditionary, Middle East, and Central Mediterranean Forces, both as an orthopaedic specialist in charge of a large orthopaedic centre in Cairo, and as an officer in charge of a field surgery unit in Sicily and Italy. Promoted Lieutenant-Colonel, he took charge of the surgical division of a hospital in North-West Europe, and served there until his demobilisation. He was appointed O.B.E. in 1944 in recognition of gallant and distinguished service in Sicily, and the following year he was mentioned in dispatches for his services in North-West Europe. While in the Army, he met his wife, formerly Miss Vivian Weekes, whom he married in Cairo in 1941.

After the war he returned to Edinburgh to his chosen speciality of orthopaedic surgery. There followed an exceptionally busy period when, in addition to his duties in the orthopaedic department of the Royal Infirmary and at the Princess Margaret Rose Hospital, he played a notable part in the development of a comprehensive orthopaedic service for the area. It was typical of his drive that in the middle of this period he obtained the higher degree of Ch.M., and also found time to pay a visit to America.

Physically he was tall and slim with the carriage of an athlete. He first impressed by his charm and quiet self-confidence. As one knew him better, one was further struck by his composure and by the effortless order of his ways. He had a flair for methodical reasoning and the ability to organise his every activity. Everything he did was carefully considered and meticulously executed. Even the elegant neatness of his handwriting mirrored this aspect of his character. There was about him a serenity which sprang from the perfect integration of a happy home life and a dedication to his work. In his home he was both a beloved husband and father. His love and the loveliness of his home and garden bore witness to this sensibility. Here was yet another facet of his character unsuspected by many, which, with his application, created the loveliest of gardens, a garden whose full maturing he was never to enjoy. He maintained his interest in athletics, and did much for the students of the University as Honorary Consulting Surgeon to the Pollock Institute of Physical Education.

As an orthopaedic surgeon his vision embraced the full scope of his work's many problems down to the ultimate and minute detail of the individual patient's aftercare. His outlook was essentially conservative, and his opinion was sought and respected by senior and junior colleagues alike. To bear the cachet of Ewen Jack's approval was proof of worth indeed. It was typical of the man that he would not pass an opinion on any new problem until he had had time fully to consider its every implication.

His special talent of ordered thought and action served him in all branches of his work. His ability as an administrator and organiser, first tried and proved in the war, was finally

confirmed in the management of his own surgical team in the Royal Infirmary. His researches both in the laboratory and by the bedside again bore the stamp of his character and ability. He was particularly interested in lesions of the ligaments and cartilages of the knee joints, and also in the static deformities of the feet. His original experimental work on disruption of the collateral ligaments of the knee joint emphasised the importance of early operative treatment. He put his theories into practice and successfully treated several such lesions, a series which he would doubtless have published. His other contributions to the literature and his dissertation at the recent joint meeting of the Orthopaedic Associations brought credit to himself and the Edinburgh School throughout the world of orthopaedic surgery. As a teacher, his genius was the extraction and presentation of the essentials of every problem. This, coupled with his easy discourse, his quiet humour, and his obvious sympathy for the problems of his audience made him a most popular and cogent mentor. Shortly before his death he presented to a meeting of the local orthopaedic surgeons a series of cases of tuberculosis of the hip joint in children treated by the latest methods. This was one of the most impressive and at the same time thrilling presentations that any of us had ever seen, presaging, as it did, a complete change in outlook on this subject.

As a surgeon he immediately gained the confidence of his patients, a confidence which materially helped them on their way to full recovery. Again his approach was conservative, showing a meticulous attention to detail. His operative technique was an essence of the man himself, carefully planned, beautifully and gently executed, with every last detail receiving careful attention. He was a surgeon who, although he did not scorn assistance, always gave the impression that he required little. If one could fault him it was only in respect of his shyness—and an almost pathological modesty.

His future held much for him and for his School. As he lived we were aware of his worth, but it was not until his death, and the manner of it, that his full stature was revealed. After a prolonged illness he became aware that death was inevitable and was not far removed. He continued to work until three weeks before he died. It was characteristic of Ewen Jack that he finally gave up, not for his own sake, but because, in his own words, he considered that he was "a bit of a menace" to others. At home he continued to work on a paper which even his brave spirit could not drive his body to complete. Fate spared him little, but it did allow him one dispensation; that was a wife who matched and even surpassed him in courage, and whose devoted care was his comfort and support to the end. To her and their two young children goes our deepest sympathy. This family will be a never forgotten inspiration to all who have known them.

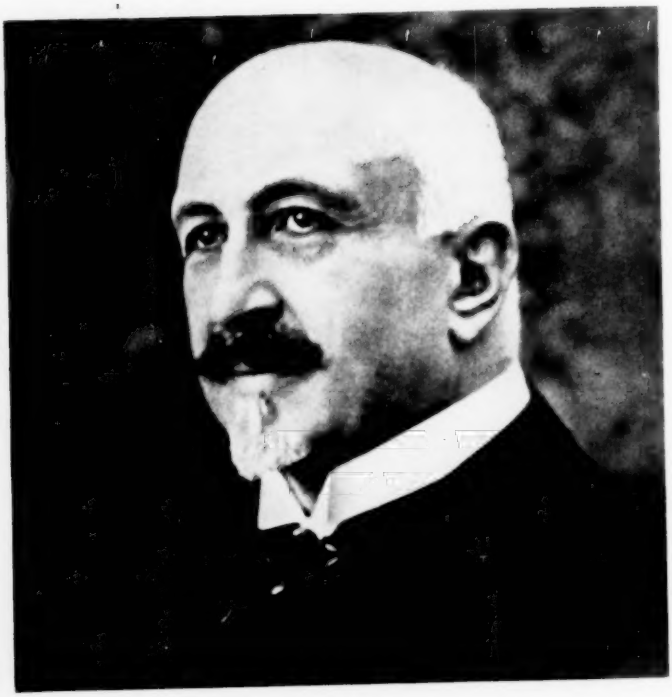
W. M. and J. H. S. S.

RICCARDO GALEAZZI

1866-1952

When Professor Galeazzi died last year Italian orthopaedic surgery lost one of its greatest personalities. For thirty-five years he was Director of the Orthopaedic Clinic in the University of Milan, and his example and leadership, both in clinical surgery and in research, were a tremendous stimulus to orthopaedic progress throughout Italy. Under his guidance the Instituto dei Rachitici grew from small beginnings to become an important orthopaedic hospital, and his influence was largely responsible for the inception and development of rehabilitation centres for the care of the crippled and injured.

His many scientific writings testify to his erudition and wide culture. Especially to be remembered is his great work on scoliosis, to which he devoted a large part of his professional life. Notable also were his studies of skeletal tuberculosis, acute arthritis of infants, and



juvenile osteochondritis. He made contributions to the treatment of chronic arthritis of adults, to the pathology of osteitis fibrosa, and to the pathogenesis of achondroplasia. He made experimental studies on bone grafts and on epiphysial cartilage transplants, and he was able to review more than 12,000 treated cases of congenital dislocation of the hip. In the field of operative surgery he introduced original techniques for the treatment of poliomyelitic disabilities, congenital foot deformities, recurrent dislocation of the shoulder and of the patella, and torn cruciate ligaments of the knee.

Among his many activities he found time to direct for thirty-five years the *Archivio di Ortopedia*, the oldest periodical devoted to orthopaedics and for many years the official journal of the Italian Orthopaedic Society.

Galleazzi's work was recognised by the conferment upon him of many honours, both in Italy and in many foreign countries. And his great friend and admirer Vittorio Putti collected together a number of important scientific papers in a volume dedicated to his honour.

O. S.

PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION

COLLECTION OF HISTORIC ARCHIVES AND TREASURES

On September 25 Sir Reginald Watson-Jones, president of the British Orthopaedic Association, and Lady Watson-Jones gave a dinner in the Library of the Royal College of Surgeons of England to mark the inauguration of a permanent collection of archives and treasures of historical interest to orthopaedic surgeons. The sixty-four guests included past presidents of the British Orthopaedic Association, present officers of the Association and members of the executive and sub-committees, with their wives. Also present were Lady Probyn Jones, daughter-in-law of Sir Robert Jones, Mrs Rowley Bristow and Mrs T. P. McMurray.

Sir Reginald, outlining the origins and purpose of the collection, paid tribute to the generosity of the relatives and descendants of pioneer orthopaedic surgeons who had presented many of their cherished possessions to the Association. Notable among the donors were Lady Probyn Jones and Mrs Hilda Watson, daughter of Sir Robert Jones. Sir Reginald told of the establishment of a new office of the British Orthopaedic Association—that of Keeper of the Archives, and he announced amid applause that Mr Rocyn Jones had that day been appointed the first holder of the office. Among the items of the collection that were of special interest Sir Reginald mentioned Hugh Owen Thomas's smoking cap and his flute, and the signet ring with which Thomas used to seal his collar-and-cuff slings to prevent interference between his visits. He read extracts from a bound set of the original letters of Evan Thomas, annotated in the handwriting of his son, Hugh Owen Thomas, which also included one precious manuscript relating to the Evan Thomas of Anglesey who was Hugh Owen Thomas's great-grandfather. Some of the letters illustrated amusingly the rivalry that existed even in those far-off days between qualified practitioners and bone-setters.

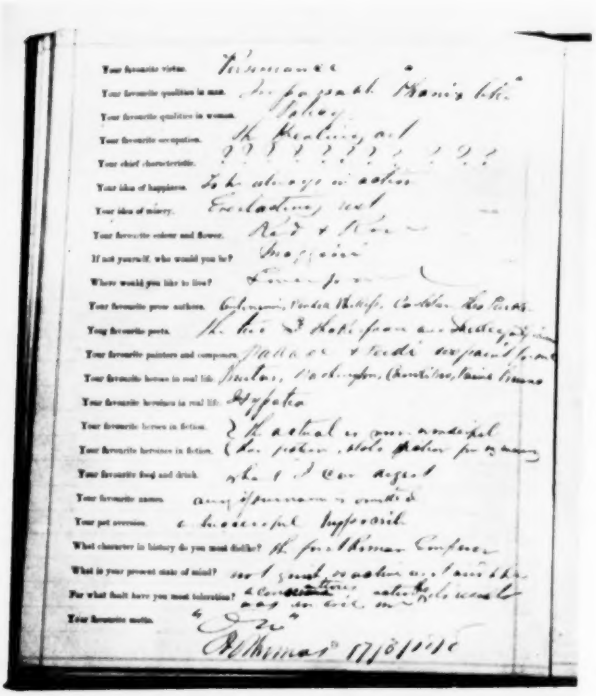
Professor Bryan McFarland, president-elect of the association, spoke of the value of cherishing mementoes of the past, the value of revering memories of our professional forefathers, the value of preserving for posterity symbols of former artists and of their art. The interest of such collections was obvious; their value lay in the power of tradition. From that power sprang the incentive to emulate and to surpass the achievements of our predecessors; from it sprang also the courage to maintain their high principles and the determination to preserve for posterity the ground that had been gained over many years by steady endeavour and sacrifice. Professor McFarland likened surgical progress to the conquest of Mount Everest. "When Hillary and Tensing this year climbed to the top of Everest they did so on the shoulders—almost literally on the shoulders—of their comrades; and the whole expedition succeeded, standing, as it were, on the shoulders of all the previous expeditions down the years. In the same way there are amongst us to-day men of talent, of distinction, and of brilliance; but they stand on the shoulders of great men of former times." This realisation induced collective pride but individual humility; it acknowledged the enduring force of tradition, and formed a sure and firm basis from which to hand on to the future these treasures of the past.

Sir Thomas Fairbank proposed the toast of the president and the president-elect. He recalled that they were the first among living orthopaedic surgeons to gain the degree of M.Ch.(Orth) at Liverpool University and he was proud to have been the co-examiner, with Sir Robert Jones, on that occasion. *Mr William Gissane* welcomed the historic collection on behalf of Dominion and other overseas surgeons.

After dinner the guests were able to examine the exhibits at leisure, and it was clear from the interest shown that the evening had been a most happy occasion for all those present. Apart from the treasures already mentioned, other items included Hugh Owen Thomas's catechism in Welsh; portrait of Robert Jones by Copnall; Robert Jones's publications, specially bound; the instrument used by Hugh Owen Thomas for percussion of bone, with his name inscribed on it; one of the only two Robert Jones Gold Medals ever presented; programme of the Joint Meeting of Orthopaedic Associations of the English-speaking World signed by Her Majesty Queen Elizabeth the Queen Mother and Her Royal Highness Princess Alice; collection of photographs of past and present

Hugh Owen Thomas's smoking cap

Hugh Owen Thomas's signet ring.



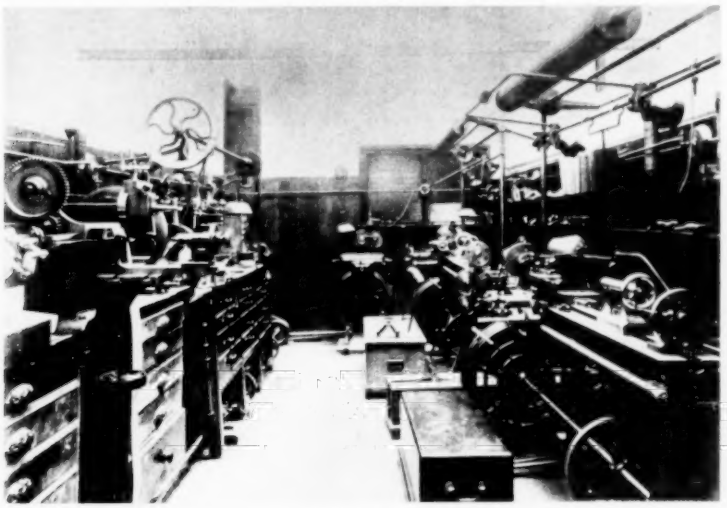
Your favourite virtue. Perseverance
Your favourite qualities in man. Perseverance
Your favourite qualities in woman. Patience
Your favourite occupation. The healing art
Your chief characteristic. ? ? ? ? ? ? ? ? ? ?
Your idea of happiness. To be always in action
Your idea of misery. Everlasting rest
Your favourite colour and flower. Red & Rose
If not yourself, who would you be? Socrates
Where would you like to live? Rome
Your favourite prose authors. Carlyle, Victor Hugo, Carleton, the Bible
Your favourite poets. The Bible & Hohl from a distance
Your favourite painters and composers. Raffaelle & Beethoven
Your favourite heroes in real life. Paulus, Washington, Carleton, Saint Simon
Your favourite heroines in real life. Hypatia
Your favourite heroes in fiction. The actual is ever wonderful
Your favourite heroines in fiction. Che poteva, Mole Italian for so many
Your favourite food and drink. Tea & I Can digest
Your favourite names. Any if pronounced correctly
Your pet aversion. A successful hypocrite
What character in history do you most dislike? The first Roman Emperor
What is your present state of mind? not I sent to action as I am like
For what fault have you most toleration? A Conscientious calm
Your favourite motto. [illegible]
H. Owen Thomas 17/8/1876

Hugh Owen Thomas's flute and in his handwriting his own "confessions" in the form of autograph albums of that day. Note his favourite virtue *perseverance*, his idea of happiness *to be always in action*, his idea of misery *everlasting rest* and his pet aversion *a successful hypocrite*.

presidents of the British Orthopaedic Association; the first Edward Hallaran Bennett Medal ever cast; one of the fifteen specially bound copies of the half-century number of the *Journal of Bone and Joint Surgery*; letter from His Majesty King George VI, approving the first number of the British Journal; Hugh Owen Thomas's confessions in his own handwriting; pen and ink drawings of specimens in the Musée Dupuytren, Paris, by Thomas Fairbank; sepia drawings of specimens in the Musée Dupuytren, Paris, and early editions of John Poland, Murk Jansen, Hugh Owen Thomas and Riellon.

In addition, Mr W. E. Thompson, Clerk of the Museum of the Royal College of Surgeons of England, had prepared a display of historic instruments in the possession of the College, and Mr W. Le Fanu, Librarian, showed historic books from the College library including a first edition of Andry's *Orthopaedia*.

The collection of archives and treasures is to be housed mainly at the Royal College of Surgeons in Lincoln's Inn Fields, but it is proposed that smaller collections of treasures shall be kept at the centres whence they originated.



Hugh Owen Thomas's lathe room, at 11 Nelson Street, Liverpool, where he constructed his own splints, frames and instruments.

TRAVELLING FELLOWSHIPS IN ORTHOPAEDIC SURGERY

from Great Britain and the British Commonwealth to the United States of America in 1954

Applications are invited from Fellows, Members and Associates of the British Orthopaedic Association, whether resident in Great Britain, Ireland or elsewhere in the British Commonwealth of Nations, for election as Travelling Fellows to visit orthopaedic centres in the United States of America and Canada for an eight-week tour (including the time of transatlantic travel). Five travelling fellows will be appointed by the president of the British Orthopaedic Association on the recommendation of the Joint Committee for Postgraduate Orthopaedic Education. In the election, preference will be given to senior orthopaedic registrars, and surgeons who have gained orthopaedic consultant appointments within the last few years.

Twenty typewritten copies of the application should reach the secretary of the British Orthopaedic Association, 45 Lincoln's Inn Fields, London, W.C. 2, not later than December 31, 1953, stating name, address, telephone number, age, qualifications, medical school, and present appointments, together with an outline of previous experience and academic or literary achievements. The application must be supported by a referee who is a fellow of the Association.

If any young surgeon who is not already an associate of the British Orthopaedic Association wishes to apply, he should communicate with Miss Barbara Key at 45 Lincoln's Inn Fields who will send the necessary forms.

UNIVERSITY OF LONDON

INSTITUTE OF ORTHOPAEDICS

Clinico-Pathological Conference on Cartilaginous Tumours of Bone

Dr Henry L. Jaffe, Director of Laboratories, Hospital for Joint Diseases, New York, conducted a Clinical Conference at the Institute of Orthopaedics on June 10 in collaboration with Dr H. A. Sissons, Morbid Anatomist to the Institute and to the Royal National Orthopaedic Hospital, with Mr H. Jackson Burrows in the Chair.

Cases illustrating the various types of cartilaginous tumours of bone were presented by Messrs J. C. McNeur, M. Singer, M. F. Pilcher, J. H. Shelswell and T. L. Carr; the pathology of the cases was outlined by Dr Sissons, and a commentary on each type of tumour was given by Dr Jaffe.

Benign chondroblastoma (a case of benign chondroblastoma of the humerus. See Figures 1 and 2)—*Dr Jaffe* outlined the development of ideas on benign chondroblastoma, sometimes referred to as the "Codman tumour," "epiphysial giant-cell tumour" or "benign calcifying giant-cell tumour." Its clinical features were as follows. 1) Nearly all the patients were boys, usually between the ages of fourteen and eighteen years. 2) The lesion was almost always in the epiphysis of a long bone, and usually extended over the epiphysial line. 3) Though at first believed to occur only at the upper end of the humerus, it could occur also in other bones such as the tibia, calcaneum or ilium. 4) Although histologically very cellular, and readily mistaken for a malignant tumour, it was benign. The tumour had been called benign chondroblastoma, firstly, to separate it from the giant-cell tumours, and secondly, to describe its basic cell, which resembled a chondroblast. *Dr F. Campbell Golding* asked if these tumours ever became malignant. Dr Jaffe considered that they did not, and that the correct treatment was curettage; they did not respond well to radiotherapy.

Central enchondroma (cases of enchondroma of a metacarpal bone and of the fibula)—*Dr Jaffe* said that the solitary benign tumours—usually seen in the metacarpals and phalanges—occurred less often in long bones, where they were more likely to become malignant. Histologically, the tumours showed some differences from the lesions of multiple enchondromatosis. The radiographic appearance varied with the degree of calcification. In answer to a question by *Mr H. Jackson Burrows*, Dr Jaffe said that there was no easy explanation for the benign character of the tumours of the bones of the hands and feet. In answer to *Mr H. J. Seddon*, he commented that it was not possible to state the chances that a central chondroma of a long bone would become malignant; he thought that if such a tumour had produced symptoms through a spate of growth it should be surgically removed, even if with difficulty.

Central chondrosarcoma (a case of chondrosarcoma of the humerus and two cases of chondrosarcoma of the femur)—These cases illustrated the variation in the degree of malignancy among chondrosarcomas, and its assessment in particular cases was presented as a matter of, often, considerable difficulty. *Dr Jaffe* commented on the importance of clinical and radiological evidence about rate of growth. In biopsy diagnosis, much cellularity and, in particular, the presence of binucleate cells were important indications of malignancy. Such histological evidence, however, might be present only in occasional areas of a tumour that otherwise appeared benign. Biopsies should be of adequate size, and taken from the growing tissue at the periphery. The pathologist should carefully examine many fields. Adequate resection was essential, although amputation could sometimes be avoided by careful local removal. Dr Jaffe illustrated the permeation of tumour tissue into the Haversian canals of the surrounding cortical bone, a feature of some chondrosarcomas that made their local resection unlikely to succeed.

Peripheral chondrosarcoma (a case of peripheral sarcoma supervening on an exostosis of the tibia)—*Dr Jaffe* said that these tumours very rarely arose from a solitary exostosis, but occurred in at least 11 per cent of cases of multiple exostoses. In the former they arose from the cartilage cap of the lesion, but in the latter he believed they had a subperiosteal origin from inconspicuous foci of ectopic cartilage. The tumours were usually chondrosarcomas, in contrast to fibrosarcoma in the present case.

Chondromyxoid fibroma (a case of chondromyxoid fibroma of the tibia. See Figures 3 and 4)—*Dr Jaffe* described chondromyxoid fibroma as a tumour with a characteristic histological structure of "chondroid" tissue and "myxoid" fibrous tissue, occurring in adolescents or young adults, appearing radiologically as well defined radiolucent eccentrically situated tumours of the metaphysial regions of long bones. Confusion with chondrosarcoma was frequent, and Dr Jaffe himself first became aware of the lesion when studying cases of supposed chondrosarcoma showing unexpectedly long survival after local surgery.

FIG. 1

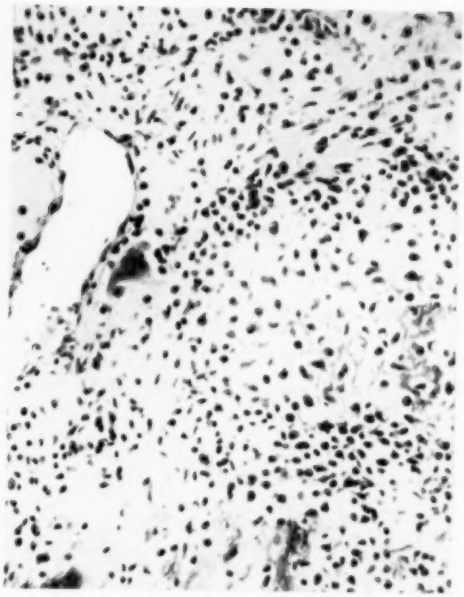


FIG. 2

Benign chondroblastoma.—Radiograph (Fig. 1) and photomicrograph (Fig. 2) (× 150) of a tumour of the left humerus of a boy aged thirteen years. Histologically, these tumours are characterised by cellular "chondroblastic" tissue, giant cells and scattered calcification.

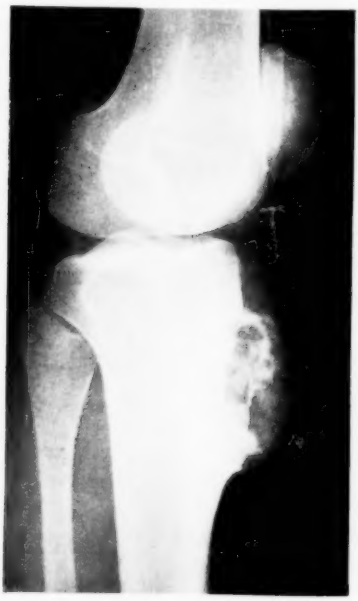


FIG. 3

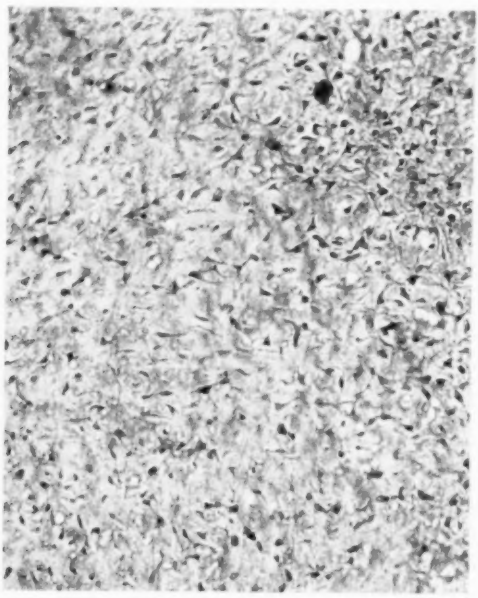


FIG. 4

Chondromyxoid fibroma.—Radiograph (Fig. 3) and photomicrograph (Fig. 4) (× 100) of a tumour of the left tibia in a woman aged twenty-one. Note the somewhat cartilaginous "myxoid" tissue of the tumour, and the elongated or stellate cells.

INSTITUTE OF ORTHOPAEDICS AND PATHOLOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

Slide seminar on tumours of bones and joints—*Dr Henry L. Jaffe* conducted a slide seminar on tumours of bones and joints, arranged by the Institute of Orthopaedics and the Pathological Society of Great Britain and Ireland, at the Institute of Pathology, Belfast, on July 2, 1953, with Dr H. A. Sissons in the Chair.

The meeting occupied a full morning and took the form of commentaries on a series of cases which included examples of osteoid osteoma, benign chondroblastoma, chondromyxoid fibroma, giant-cell tumour of bone, fibrous dysplasia of bone, and pigmented villonodular synovitis, together with some cases in which diagnosis was uncertain. Clinical abstracts, radiographs and histological sections had been circulated beforehand. Discussion followed each group of cases, and the meeting gave British pathologists an opportunity of gaining first-hand acquaintance with some of the " entities " described in the literature by Dr Jaffe and his colleagues. Attention was particularly directed to the bone tumours occurring in Paget's disease. Dr Jaffe put forward the view that these were often of complex histological structure. Sections of a single tumour sometimes showed in different areas the characteristic appearance of osteogenic sarcoma, fibrosarcoma, chondrosarcoma and, in addition, areas of giant-celled tissue. In some cases the giant-celled tissue predominated, but despite this Dr Jaffe did not regard these tumours as " malignant giant-celled tumours."

UNIVERSITY OF LIVERPOOL

VISIT OF DR H. L. JAFFE

The Departments of Orthopaedic Surgery and Pathology of Liverpool University were very pleased to entertain *Dr Henry L. Jaffe* on June 18 and 19, and a large programme was packed into his all-too-short stay.

On the morning of June 18, he was an amused observer of that part of the Final M.B. Clinical Examination that concerned orthopaedics. In the afternoon he delighted a large audience of staff, postgraduates and undergraduates with the remark that Liverpool plainly was not the place for a set formal lecture, and that he had torn up his script and rearranged his slides. He proceeded to give a most interesting talk on **fibrous dysplasia of bone,** illustrated with a wealth of magnificent colour microphotographs. At the end he added a make-weight on **osteoid osteoma,** with fully documented and illustrated cases, which was really another lecture in itself. In the evening, the orthopaedic surgeons and pathologists dined Dr Jaffe.

On June 19, six unusual lesions of bone and joint were presented in detail to Dr Jaffe for his comment, and much interesting discussion followed.

UNIVERSITY OF GLASGOW

BONE TUMOUR CONFERENCE

Dr Henry L. Jaffe of the Hospital for Joint Diseases, New York, visited Glasgow on June 28–30, 1953, and conducted a bone tumour conference.

Giant-cell tumour of bone—On June 29 Dr Jaffe delivered a University Lecture on giant-cell tumour of bone. He defined this tumour and showed wherein it differed from its so-called variants, stressing the histological features of these but indicating also their sites, age and sex incidences and how these characteristics were more dependable than the radiographic appearances. Giant-cell tumours were often malignant, and radiotherapy seemed to increase the liability to malignant change; the name osteoclastoma was not justifiable. He appealed to pathologists always to prepare as many blocks as possible from resected specimens, and indicated in general that personal proficiency in bone tumour diagnosis and the general advancement of this science could come only from very thorough study of all available tissue.

Radiographic and histological demonstration—A collection of thirty rare or difficult cases from the Glasgow area was open in the pathology department, the Western Infirmary, during the period of the conference. Each case was shown as the problem it presented at the time of operation, and the follow-up data were meantime withheld. On the afternoon of June 30 Dr Jaffe, using a microprojector, dealt convincingly with the most interesting of these cases. He stressed in particular the importance of recognising chondromyxoid fibromas, and of differentiating between chondrosarcomas and those osteogenic sarcomas that showed much cartilage formation. A chondrosarcoma was a malignant tumour arising in adult cartilage and composed of anaplastic and neoplastic forms of cartilage; the prognosis after amputation was relatively good. Osteogenic sarcoma was a malignant tumour arising in primitive bone mesenchyme which might form aberrant myxoid, chondroid or cartilage, and osteoid; it had a poor prognosis even after early amputation.

At the week-end the same assiduous enquiry, eye for detail, and retentive memory were exercised on the phenomena of the Scottish countryside, and Dr and Mrs Jaffe were throughout most charming guests.

SCIENTIFIC SOCIETIES AND REGIONAL ORTHOPAEDIC CLUBS

THE BONE AND TOOTH SOCIETY

Symposium on jaw lesions—This symposium was held at the Institute of Orthopaedics, Royal National Orthopaedic Hospital, on July 7, 1953, with Mr I. R. Kramer in the Chair.

Adamantinoma—*Dr R. B. Lucas* said that this was an epithelial tumour bearing a structural resemblance to certain elements of the odontogenic apparatus. The tumour occurred in the jaws, more often in the lower than in the upper, and, though neoplasms of somewhat similar appearance arising in the long bones, the ovary, the pituitary and the pharynx had also been characterised as adamantinomata, it was very doubtful whether there was a true genetic relationship. The typical adamantinoma showed a follicular structure, consisting of nests or islets of epithelium in a fibrous stroma, the epithelial elements being composed of an outer layer of cubical or columnar cells enclosing an area of stellate cells resembling the stellate reticulum of the enamel organ of the developing tooth. Cyst formation within the epithelial follicles, or in the fibrous stroma, was common. Epithelial cyst formation was often accompanied by degenerative changes of the stellate cells, which produced an appearance superficially resembling squamous metaplasia and keratinisation. True squamous metaplasia in the adamantinoma was probably uncommon. Stromal cyst formation might produce an appearance not unlike that shown by the areas of proliferating but non-neoplastic epithelium which often occurred at the site of inflammation or in the walls of dental and dentigerous cysts. Solid forms of adamantinoma also occurred, which might be difficult to diagnose histologically in biopsy specimens. In all cases of difficulty, further material should be examined.

Osteolytic primary tumours of the jaws—*Dr C. H. G. Price* said that these accounted for only 3·7 per cent of all tumours in the Bristol Bone Tumour Register Collection 1946–53. The lesions classified as localised fibrous dysplasia and giant-cell tumour amounted to a further 6 per cent. The clinical, radiological and histological features of the tumours were described and discussed in the light of their characteristic behaviour in the general skeleton. Factual histological classification was preferred to inconclusive histogenetic considerations, these being related to atypical tissue of differentiation. The problems of histological assessment of malignancy were indicated, with special reference to estimation of growth rate by quantitative mitotic analysis. It was emphasised that prognosis was inferred from comprehensive appreciation of tumour type, site, stage, histological grading, contributory skeletal disease and possible type mutation. With the frankly malignant growths it was shown that the five-year cure rate was approximately the incidence of tumours of Grade I malignancy, and that in this grade cures could be expected from local surgery or radiotherapy only.

Fibrous dysplasia of the jaw bones—*Dr P. C. Meyer* had found every gradation from affection of only one bone to the comparatively rare affection of several. From a review of the literature it appeared that jaw lesions might show any of the variations of histological structure found in the skeleton in generalised fibrous dysplasia. Dr Meyer described some examples in which the jaw was involved. These included that of a middle-aged man who was cured by partial removal of the dysplastic tissue.

SOUTH-EAST METROPOLITAN REGION ORTHOPAEDIC CLUB

A meeting of the South-East Metropolitan Region Orthopaedic Club was held at the Royal Sea Bathing Hospital, Margate, on July 4, 1953. Over forty members and guests were present.

Congenital affections of the skeleton—*Mr F. G. St Clair Strange* (Canterbury) described a veritable museum collection of congenital affections of the skeleton.

Tuberculosis of the knee joint—*Mr P. R. Wright* (Margate) showed six cases of tuberculosis of the knee joint under treatment by immobilisation and systemic streptomycin. The rapid improvement in symptoms and signs was notable, but in two cases mild activity had recurred when weight bearing was resumed. The place of synovectomy in the treatment of tuberculosis of the knee joint was discussed.

Acute osteomyelitis of the cervical spine—*Mr P. R. Wright* also showed a case of acute osteomyelitis of the cervical spine in an elderly woman. The infection was complicated in its early stages by partial paraplegia, which had resolved completely with conservative treatment. The patient was now walking, the neck being protected by a collar. There were no residual neurological signs.

Infective arthritis of the ankle joint—*Mr M. L. Mason* (Margate) showed a patient with infective arthritis of the ankle joint with a focus of bony destruction in the talus. The case presented all the clinical features of tuberculous arthritis but the Mantoux reaction was repeatedly negative. The infection had settled well on conservative treatment and the patient was walking in plaster. Biopsy hardly seemed justifiable in these circumstances.

Pes calcaneo-cavus—*Mr M. L. Mason* showed a boy with severe pes calcaneo-cavus following poliomyelitis. There was complete paralysis of the posterior calf muscles, but all other muscles remained active. Despite his very ugly foot, this adolescent boy complained of no pain and could walk, run and play football. The danger of impeding function while improving the appearance of this foot by attempts at operative correction was emphasised in discussion, and the consensus of opinion supported Mr Cholmeley's plea for masterly inactivity unless symptoms arose to necessitate surgical treatment.

Adolescent hallux valgus—*Mr Mason* presented a further case for discussion: that of a hallux valgus in a girl of fourteen with metatarsus primus varus. The various forms of operative approach to this problem in the young were discussed, and though Mr T. T. Stamm's method found some support, the suggestion was put forward by Mr W. H. Gervis that conservative treatment, and especially the correction of general faults in posture, had an important part to play in the treatment of this and other similar cases.

Surgery for deformities complicating disseminated sclerosis—*Mr Mason* asked the opinions of members on a case of spastic paraplegia in disseminated sclerosis in a middle-aged woman with gross fixed flexion and adduction deformities of both lower limbs. The usefulness of tenotomies and muscle slide operations in certain cases of this sort was mentioned by Mr W. D. Coltart and Mr H. L.-C. Wood. They emphasised the value of post-operative nursing in a bivalved double plaster spica to allow daily inspection of the skin.

Other cases—*Mr P. R. Wright* showed a child of seven who had a torn lateral semilunar cartilage. *Mr Basil Armstrong* (Margate) showed an adolescent girl with avascular necrosis affecting a sector of one femoral head, and another child with periostitis of the femoral shaft associated with tuberculosis elsewhere.

History of the Royal Sea Bathing Hospital—*Mr Basil Armstrong* gave a most interesting historical survey of the Royal Sea Bathing Hospital from its foundation at the end of the eighteenth century to the present day. He recalled that until about 200 years ago the health value of the summer holiday at the seaside had not been appreciated, though the waters of inland spas such as Bath and Tunbridge Wells had been used as curative for centuries. Richard Russell ("Sea-Water" Russell), son of a surgeon-apothecary practising at Lewes, while apprenticed to his father, fell in love with the daughter of a wealthy patient and married her clandestinely. Forgiven by his bride's father who encouraged him to rise above the rank of an apothecary and qualify as a physician, Russell studied at Leyden, and on his return to England started in practice at Lewes. On the death of his father-in-law, he left Lewes to practise at Malling Deanery which he inherited through his wife.

Russell had been impressed by the virtues of sea-water which he used internally and externally in the cure of enlarged glands, and produced two books on the subject which had a wide circulation. His books made him famous and at the age of sixty-three he moved to Brighton, where he built a house and practised until his death in 1759. Brighton, or Brighthelmstone as it was then called, became much patronised by the wealthy. The Duke of Cumberland stayed there annually for his health, and probably George III would have been sent there also instead of to Weymouth for convalescence after his attacks of madness had it not been that he disliked his brother so much; and it is equally probable that it was to annoy his father that the Prince of Wales visited his uncle at Brighton and then started the memorable days of the Pavilion which established its fortune at the beginning of the nineteenth century.

John Coakley Lettsom, a well known Quaker physician of the day, a man of extraordinary energy and versatility—he was a founder member of the Medical Society of London and the Royal Humane Society, a protagonist on behalf of Jenner in the great inoculation controversy, a pioneer for prison reform, and a man of much wealth and benevolence—conceived the desire to make available to the poor what was useful to the wealthy, and he hit upon the idea of starting a hospital for them at Margate. A meeting of Lettsom and some eight others was held at the London Coffee House on July 2, 1791, when Lettsom explained his scheme and was authorised by the meeting to go to Margate with Mr Nichols and Dr Pridden to select and purchase a site for the hospital. This was done, two acres of ground at Westbrook being obtained for the sum of £300; a local committee was formed and further London meetings were held during the month of July. The hospital was opened five years later, having been built to a plan inspired by Lettsom and drawn up by the Rev. John Pridden, who was an antiquary and amateur architect. He designed the original building illustrated in Lettsom's "Hints on the formation of a Sea Bathing Infirmary," and it is noteworthy that his design made provision for patients to live and sleep on verandas in the open air, a thing previously unheard of in hospital architecture.

The ease of access from London, either by coach or by sea, was one of the principal reasons for the selection of Margate as the site of the hospital. Stage coaches took about fourteen hours

on the journey, their fare being 16s. to 19s. The Hoys, single-deck sailing ships which plied between Margate and the London Docks, had good accommodation for patients at £2 6s each and were consequently more widely used than the coaches.

During its early years the Sea Bathing Infirmary was open only in the autumn, from August to December. Sixteen patients were admitted during its first year, but by 1800 the number had risen to eighty-six.

Lettsom continued, until his death, to take a keen personal interest in the hospital. He visited it at least once each year, examining the patients, attending a religious service at which the collection was devoted to the hospital, and later a dinner where again a collection on behalf of the hospital was made. The Sea Bathing Infirmary increased steadily in size after his death, being enlarged in 1816, 1837, 1858, 1882 and 1919, and the original thirty patients are now augmented to 300. Its title was changed to the Royal Sea Bathing Hospital in 1898. It was the first hospital in the world in which open air treatment had been systematically practised.

EAST ANGLIAN ORTHOPAEDIC CLUB

A meeting of the East Anglian Orthopaedic Club was held on January 31, 1953, at the East Suffolk and Ipswich Hospital, Ipswich. Clinical cases were demonstrated.

Osteomyelitis of the spine—*Mr E. Bell Jones* (Ipswich) showed a case of a man of eighteen with a febrile illness, a raised sedimentation rate and pain in the back. The radiographs showed narrowing of the joint space between T 11 and 12 and of the manubrium sterni. This was presented as a case of ankylosing spondylitis, but Dr J. Phelan, who supervised the x-ray treatment, expressed some disagreement with the diagnosis on the grounds that the onset was too acute and that the radiographic changes in the sacro-iliac joints were unconvincing. He showed special oblique views of the sacro-iliac joints which showed the joint space to be present. He was of the opinion that this was a case of a low-grade osteomyelitis.

Tuberculosis of the spine—*Mr E. Bell Jones* showed a second patient who came under observation as a case of tuberculous spine with a psoas abscess but this was not substantiated by further investigation and the possibility of its being a case of ankylosing spondylitis was discussed.

Tuberculosis of the ankle—*Mr E. Bell Jones* showed a case of a tuberculous ankle in a patient with a positive Mantoux reaction and abscess formation. Out-patient treatment by daily injections of streptomycin was given; it was felt that the splintage that had been prescribed had not been carried out, for the boy developed a march fracture during the course of treatment.

Tuberculosis of the knee—*Mr E. Bell Jones* showed a further case of painful synovitis of the left knee and miliary tuberculosis of the chest. A year after the patient's discharge from hospital the joint flared up and he reported with a flexed, painful and inflamed knee. Biopsy showed tubercle bacilli. He was treated by streptomycin. Six months later a biopsy showed a normal synvoial membrane, but in spite of this ankylosis was completed surgically. *Mr M. C. Wilkinson* (Black Notley) said that no antibiotic could be expected to take the place of properly conducted general treatment and that after treatment by streptomycin the synovial membrane might produce a histological picture difficult to diagnose and needing special experience. To make antibiotics effective, operation must often be carried out, because little streptomycin might reach the bone without it. He believed in the value of a partial synovectomy in the treatment of tuberculous joints. *Mr Noel Smith* (Peterborough) supported the value of synovectomy with streptomycin and maintained that the removal of 70 per cent of the synovial membrane gave nature a chance to produce a normal joint.

Osteitis of the ilium—*Mr T. Denness* (Ipswich) showed a case of a girl of thirteen who complained of pain over the iliac crest for three months. The pain was aggravated by running. There was some swelling at the site of the pain. Radiographs showed a layer of calcification parallel to the crest but separate from it. Later radiographs suggested that this change was probably infective, though the possibility of a neoplasm had been suggested by the earlier films.

Osteochondritis of the radial head—*Mr T. Denness* showed a boy of thirteen with pain in the elbow joint. Radiographs showed a fragmented radial head but the fragment did not unite and the possibility of its origin from an osteochondritis of the radial head was discussed. Normal function was regained but there was some cubitus valgus. There was some discussion as to whether or not the fragment of bone should be removed, and there was no general agreement whether the diagnosis should be osteochondritis or fracture.

Ankylosis of hips—*Mr K. L. Marks* (Ipswich) showed a patient with bilateral ankylosis of the hips treated by a subtrochanteric osteotomy on one side and later a Jones type of pseudarthrosis on the other. The functional result was good.

Osteochondritis dissecans—*Mr K. L. Marks* demonstrated a case of osteochondritis dissecans in the right ankle. *Mr T. J. Fairbank* (Cambridge) suggested that these cases began as fractures into the ankle joint and that a fragment of articular cartilage became detached in that way.

Monteggia fracture—*Mr E. Bell Jones* showed a case of dislocation of head of the radius with fracture of the ulna. Attempts at reduction failed. A medullary nail was inserted and this proved an expeditious method of treatment.

Fractured femur—*Mr D. M. Kerr* (Ely) showed a case of medullary nailing for a fracture of the mid-shaft of the femur. Fracture of the nail occurred six months after the original injury. Six months later he fell again and fractured the neck of his femur. The medullary nail was removed and a Smith-Petersen nail inserted.

Osteoclastoma—*Mr R. C. Hoiyard* (Norwich) showed the radiographs of a bone tumour for diagnosis. These were the films of a boy who, at the age of fourteen, received a blow on the shin from a cricket ball. The appearance of the tibial lesion gave the impression of a simple cyst, but a second radiograph showed periosteal new bone. At biospy a brownish fluid was removed which contained several giant cells, and the diagnosis of osteoclastoma was suggested. Six weeks later he sustained a fracture into the cyst. While the limb was in plaster the biopsy scar broke down and a fungating mass developed. A second biopsy showed nothing more than blood clot in the mass, with a few scattered giant cells. The opinion was expressed by members that this condition had probably been malignant from the beginning.

Dr J. Phelan (Ipswich) spoke of his experience with the changes in some of these cysts after trauma which gave appearances resembling a sarcoma and reported that there was difference of opinion as to whether they were malignant or not. He was of the opinion that they were a form of giant-cell tumour whose behaviour was altered by the increased vascularity after injury.

A further meeting of the Club was held at the West Suffolk General Hospital, Bury St Edmunds, on March 28, 1953. Clinical cases were shown.

Osteomyelitis—*Mr D. J. Martin* (Bury St Edmunds) showed radiographs of two boys with osteomyelitis of the femur and tibia respectively which had not responded to antibiotics. He discussed the place of surgery and how extensive it should be. The failure of antibiotics to be an effective means of treatment alone could be due to delay in beginning treatment, to inadequate dosage, to to insensitivity of the organism. Operation was sometimes delayed too long, so that bone was already dead, and it was often not sufficiently extensive. A discussion followed in which other members agreed that when antibiotics were used it was not so easy to decide on the right time to operate. It was agreed that it was better to operate too soon than too late; that if pus was found under the periosteum the cortex should be drilled; that if pus escaped from the drill holes the medullary cavity should be channelled; and that the wound should be closed by primary suture.

Unusual cases—*Mr Martin* then showed a series of curiosities. **Toxoplasmosis**—The girl attended with injuries from falling in a fit. The radiograph of the skull showed the characteristic crescentic calcifications in the brain. One eye also showed old choroido-retinitis. **Eosinophilic granuloma**—A small child with a soft swelling in the skull which showed radiographically a clear and localised osteolysis. The blood chemistry and sternal puncture were normal and the blood picture showed a slight excess of eosinophils. While under observation over six months the swelling disappeared, as did the area of transradiancy in the skull. Radiographs of the rest of the skeleton showed no other abnormality. No biopsy was made. **Infantile cortical hyperostosis**—The baby was first thought to have osteomyelitis of the jaw, but the condition subsided spontaneously, only to come up again. Radiographs taken on the second admission showed the additional layer of bone on the cortex of the mandible, and possibly also of the clavicle. Other bones were not affected. Members spoke of cases they had seen affecting the scapula, ribs and pelvis. **Osteochondral dystrophy**—This man had had a grossly enlarged left arm since birth. The thumb was seven inches long, deformed and useless. He carried it hidden in a linen bag and was unwilling for it to be seen, nor would he allow anything to be done to it. He had come into hospital for some other unconnected reason.

Radiotherapy for orthopaedic affections—*Dr M. Bennett* (Cambridge) showed a number of cases referred from the orthopaedic department for radiotherapy. The first was a case of a secondary deposit in the pelvis from a carcinoma of the breast removed five years before. This had eroded the ilium to such an extent that a fracture had occurred through the acetabulum into it. Treated with x-radiation and testosterone, the bone re-formed and the growth disappeared, leaving a large gap in the ilium. The second case shown was one of osteoclastoma of the sacrum. The patient had sought advice for sciatic symptoms. The nature of the growth was established by biopsy. Treatment was by x-radiation, but the ureters became involved and she died from pyonephrosis. Some difference of opinion was expressed about the value of x-rays in treating these cases, but Dr Bennett believed that good results could be obtained in many cases with efficient treatment. He would prefer to treat the tumour from the beginning rather than after it had been " scraped out " by a surgeon.

Osteoporosis of the spine—*Dr M. Bennett* showed a case. At first the patient had been thought to have secondary carcinomatous deposits in the vertebrae, but this diagnosis was given up as the patient was observed, for extension of the disease did not occur and the osteoporosis of the vertebrae was generalised. *Mr D. J. Martin* showed radiographs of two other cases of senile osteoporosis and *Mr R. W. Butler* (Cambridge) showed the films of a boy with pulmonary tuberculosis whose spine had assumed an appearance exactly similar. The use of butazolodine for the relief of pain and the use of dicalcium phosphate was recommended by other speakers.

Perthes disease—*Mr D. J. Martin* showed radiographs of children with Perthes disease. He disagreed with the statement made by Legg: "While a process suggesting weakness of bone structure is going on, it is theoretically sound to allow no weight bearing, but in practice relief from weight bearing in no way affects the end results." He believed that the occurrence of osteoarthritis of the hip after Perthes disease in childhood would be evidence against this contention. He made a plea for treatment with bed rest and light traction for many months—perhaps a year—until some regeneration was seen to be taking place, followed by the use of a patten-ended caliper on the affected side and a patten on the other.

A further meeting of the Club was held at the Thorpe Hall Rehabilitation Centre, Peterborough, on June 6, 1953. Clinical cases were demonstrated.

Myelography for prolapsed disc and spinal tumours—*Mr K. L. Cleminson* (Peterborough) demonstrated, with a series of radiographs, the value of myelography in the diagnosis of protrusion of intervertebral discs. It enabled the site of the lesion to be determined and helped to differentiate a displaced disc from spinal tumour.

Infantile cortical hyperostosis—*Mr Noel Smith* (Peterborough) showed films of two cases of this condition and discussed the differential diagnosis. Mr Bell Jones made the comment that since the previous meeting of the Club he had seen a child with this condition and thought it remarkable that four cases of this rare condition should have been reported in the region in so short a time.

Metaphysial aclasis—*Mr Noel Smith* showed a case of metaphysial aclasis in which the predominant symptom was pain in the shoulder. Radiographs showed an exostosis on the scapula and further studies revealed similar exostoses on many other bones. It was proposed to remove the exostosis on the scapula.

Obliteration of brachial artery by crutch pressure—*Mr K. L. Cleminson* described obliteration of the brachial artery by crutch pressure in a man who had suffered from extensive paralysis from anterior poliomyelitis at the age of two years. He had used T-shaped crutches all his life, but recently he had noticed coldness and cyanosis of his hand. There was a contracture of the fingers similar to that of Volkmann's ischaemic contracture. An arteriogram showed a block in the first part of the axillary artery. At operation the artery was found to be blocked as far down as the elbow. Treatment was discussed. Stellate ganglionectomy and division of the scalenus anterior were suggested.

Fibrosarcoma of tibia—*Mr Noel Smith* showed an operation specimen of a fibrosarcoma of the tibia. The patient was first seen in 1946, when the growth was removed locally and the gap bridged by a cadaveric graft and bone chips from the ilium. Healing progressed for ten months, when it was found that the growth had recurred; amputation above the knee was therefore carried out. Some discussion on the value of x-ray treatment followed.

Senile gangrene—*Mr Cleminson* discussed the use of intra-arterial vasodilators in the case of incipient or established senile gangrene and described his technique and the preparation used.

Multiple fractures—*Mr Noel Smith* demonstrated the value of medullary nailing in a case of refracture of the mid-shaft of femur and another of refracture at the site of a bone graft for subtrochanteric fracture. Two further cases of multiple fractures were shown: one followed electric convulsive therapy; the other was in a child of three years without blue sclerotics and in whom the question of maltreatment was considered. He then showed a case of massive loss of bone from a humerus after an industrial accident. The fracture had been treated with a tibial graft to bridge the gap; eight months after the operation the arm was stable but the elbow was rather stiff.

Fracture through cyst of tibia—*Mr G. K. McKee* (Norwich) showed radiographs of a girl with a fracture through a cyst in the tibia. Three years later this had developed into a fibrocystic area. The diagnosis was discussed and the suggestion that it was an example of Albright's syndrome was considered.

Paraesthesia of arm and paraplegia—*Mr R. C. Howard* (Norwich) showed the radiographs of a man of fifty-one with pain and paraesthesia in the arm and paraplegia. He had been operated upon by a neurosurgeon who had carried out an extensive laminectomy, which led to cervical

subluxation. Skull traction produced some improvement, but when the traction was removed the paraplegia returned. There were hardly any spinous processes remaining and the possibility of grafting from the skull to cervical vertebra 7 was considered. The general opinion was that skull traction should be continued in the hope that fibrosis would eventually afford adequate stability.

JOINT MEETING OF THE MANCHESTER AND LEEDS REGIONS ORTHOPAEDIC CLUBS

A joint meeting of the Manchester Orthopaedic Club and the Leeds Orthopaedic Club was held in Harrogate on June 26 and 27, 1953, at the Royal Bath Hospital.

Surgical treatment of rheumatoid arthritis—*Mr H. Petty* (Harrogate) claimed that better results would be obtained by closer co-operation between physicians and surgeons from the very beginning and throughout the whole process of the disease. He advocated earlier surgical intervention, and believed that clinical and laboratory signs of disease activity were not any contra-indications; advantage ought to be taken of the healthy state of the patient's tissues in the early stages of the disease. For the hip joint, arthroplasty was recommended early in the disease; a posterior atraumatic approach was used and an acrylic prosthesis was fitted after resection of part of the femoral head; early activity was encouraged. In the late chronic stage arthroplasty was of no value and resection of the femoral head and neck was the only operation worth considering. In the knee joint, activity of the disease despite conservative measures could be reduced either by arthrotomy and lavage or by synovectomy. Bilateral arthroplasty of the knee could give excellent results but it was better, when both knees were stiff, to have one painless stiff knee and one knee rendered mobile by arthroplasty. In the ankle joint, pain and disorganisation made early fusion imperative. In the foot much could be done for the later deformities to improve function by resection of the second, third, fourth and fifth metatarsal heads, Keller's operation, moulding and plaster fixation. Disease of the shoulder and elbow was usually controlled adequately with conservative care and seldom required operative treatment. In the early stages, if the elbow joint was almost or entirely stiff arthroplasty ought to be seriously considered because at least half the normal range of movement with good stability could easily be obtained. Arthroplasty of both elbows was not recommended because the patients found difficulty in using sticks for walking; it was better if one elbow was stiff in semi-extension to give more stability. In the wrist joint pain necessitated early fusion and the results were satisfactory. In the hand, though there might be marked deformity, function was often quite good. A judicious combination of physiotherapy and occupational therapy was often very efficacious and manipulation was frequently of value. At a clinical demonstration Mr Petty illustrated the following orthopaedic conditions occurring among "rheumatic" patients: arthritis mutilans, Sjögren's syndrome, osteoporosis and subluxation of both shoulder joints, acrylic and cup arthroplasties, cervical spondylolis with cord compression, gout, psoriatic arthropathy, gross synovial swelling of the knee, Still's disease and Klippel-Feil syndrome, gargoylism, and syringomyelia with neuropathic arthropathy of wrists.

Films—*Mr R. Broomhead* (Leeds) showed two colour films—one on the technique of the Smith-Petersen arthroplasty of the hip and one on rehabilitation after arthroplasty of the hip.

Arthroplasty of the hip—*Mr R. Broomhead* referred to arthroplasty of the hip both by vitallium mould and by the acrylic prosthesis. The following were some of his observations. 1) Many moderate results from vitallium mould arthroplasties are caused by failure to perform the operation thoroughly. 2) When the acetabulum is irregular and has to be gouged out the mould is preferable to an acrylic prosthesis. 3) Evident deafness is almost a contra-indication to operation because of the patient's inability to appreciate the post-operative instructions. 4) Post-operative progress when an acrylic head prosthesis is used is much quicker than after a mould. 5) A number of patients who have a mould in one hip and a prosthesis in the other prefer the mould because they feel it is more secure.

Development of the Leeds Region Rheumatic Centre—*Mr H. Petty* gave a short account of the history, the present position and contemplated future developments of the Leeds Region Rheumatism Centre at Harrogate. He indicated how an orthopaedic unit had been developed and what part it played in the rheumatic service. Members of the Clubs were shown round the Harrogate Rheumatism Centre at the Royal Bath Hospital, the White Hart Hospital and the Royal Bath Treatment Centre.

CANADA

CANADIAN ORTHOPAEDIC ASSOCIATION

At the Ninth Annual Meeting of the Canadian Orthopaedic Association, which was held in Winnipeg and Minaki Lodge, Ontario, from June 20–24, 1953, members were honoured by the presence as guest speaker of the president-elect of the British Orthopaedic Association, Professor

Bryan McFarland. His presence, with Mrs McFarland, added tremendously to the inspiration of both our social and scientific programmes. The members of the Canadian Orthopaedic Association, in an effort to express their appreciation in a tangible way, elected Professor McFarland an honorary member of the Association.

ITALY

ITALIAN-FRENCH ORTHOPAEDIC DAYS

The meeting known as "Italian-French Orthopaedic Days" was held in Venice on May 14 and 15, in Bologna on May 16 and in Turin on May 18, 1953. It was attended by many orthopaedic surgeons of the two countries; among them were Drs G. Huc, M. Fevre, M. Guilleminet, Ducroquet, J. Judet, E. Calandra, U. Camera, F. Delitala, E. De Marchi, C. Marino-Zuco, O. Scaglietti, R. Zanoli, some Belgian guests and others.

The programme in Venice (Ospedale Civile).—Many interesting problems were discussed. They included fractures of the femur in childhood (Dr J. Judet); Küntscher's nailing in arthrodesis of the knee joint (Dr R. Ducroquet); recurrence of solitary bone cysts after operation (Dr J. Creyssel); the treatment of the paralytic elbow (Dr P. Lecoeur); can infantile paralysis benefit from tissural therapy? (Dr E. Calandra); functional stabilisation of the flail lower limb (Dr A. Albanese); bone synthesis with tridimensional plates (Dr C. Marino-Zuco). Ciné films were shown of arthroplasty in hallux valgus by Dr R. Ducroquet, and herniae of cervical intervertebral disc (Professor O. Scaglietti).

The programme in Bologna (Istituto Ortopedico Rizzoli).—*Professor M. Guilleminet* discussed the treatment of congenital pseudarthrosis of the tibia. Ciné films were shown of arthrodesis by compression by Dr R. Zanoli and metallic endoprosthesis in resection for tumours by Dr F. Delitala.

The programme in Turin (Clinica Ortopedica).—*Professor U. Camera* discussed the problems of tuberculous coxalgia, the biological treatment of skeletal tuberculosis and the surgical treatment of osteoarthritis of the hip joint. Patients were shown to illustrate the late results. The demonstration was followed by an operating session.

SOUTH AMERICA

JOINT MEETING OF THE LATIN-AMERICAN SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY AND THE BRAZILIAN SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

The second congress of the Latin-American Society of Orthopaedic Surgery and Traumatology was held in Rio de Janiero and in São Paulo from July 18 to August 1, 1953. The conference was attended by more than five hundred orthopaedic surgeons from all the Latin-American countries and by many others from the United States of America and European countries. The guests of honour who had received special invitations included Drs Alan De-Forest Smith, Francis W. Glenn, Harold Boyd, Harry Winkler, John R. Cobb, John R. Moore and Stirling Bunnell from the United States of America; Professor R. Merle d'Aubigné and Dr Jean Judet from France; Professor F. Delitala from Italy; Dr M. Bastos Ansart from Spain; Professors G. Küntscher and Max Lange from Germany; Professor Lorenz Böhler from Austria; Professor Sten Friberg from Sweden; and Sir Reginald Watson-Jones and Professor J. Trueta from Great Britain.

The first part of the congress was held in the magnificent Quitandinha Hotel at Petropolis, a town situated in the mountains forty miles from Rio de Janeiro at 2,000 feet above sea level. The whole hotel had been booked by the organisers. Its many halls, lecture rooms and large theatre together with ballrooms, restaurants and cabarets allowed the many scientific discussions and exhibits to be combined happily with reunions and social occasions. The annual meeting of the Brazilian Society of Orthopaedic Surgery and Traumatology at the same time gave all the visitors the opportunity to appreciate the maturity which orthopaedics has reached in Brazil.

The congress demonstrated clearly the merit of organising a scientific and clinical meeting in the same premises as members were residing, many with their wives. There was a unique opportunity for all those attending the meetings to become acquainted with each other and to discuss problems of interest informally while sitting in the lounge of the hotel.

The subjects of discussion included fractures of the wrist; reticulo-endothelial and Ewing's tumour; fractures of the os calcis and scoliosis; and there were about twenty special lectures given by the guests of honour.

Apart from the value of scientific discussions aided by the excellent system of simultaneous translation, so that those attending the meeting could stay in any part of the hall and with

earphones hear a translation into his own language at the same time that the speaker was delivering his lecture in French, English, Spanish, Portuguese or German, there was tremendous success in the social activities. Visitors to Brazil must have been impressed by the facility with which the Latin-Americans and Brazilians could switch from serious scientific discussion to light-hearted entertainment and dancing.

The second part of the congress was held in the city of São Paulo which by some is known as the " New York of South America " and by others as the " Soul of Brazil." There were discussions on the treatment of skeletal tuberculosis, fractures of the upper limb in infants, recurrent dislocation of the shoulder, and fractures of the humerus. The new Orthopaedic and Accident Hospital of the Medical Faculty of São Paulo under the directorship of Professor Godoy Moreira was officially opened by the Governor of the State, Dr Lucas Nogueira Garcez. This magnificent building with its extensive accommodation and efficient organisation of services would honour any city in the world.

There was one happy evening when those attending the congress entertained each other, and the two visitors from Britain displayed " The Harley Street Surgeon in Brazil " removing large masses of metal, consisting mainly of spoons, knives and forks, from a fractured thigh, and then rehabilitating the patient with sambas and rhumbas. The occasion seems to have passed into the orthopaedic history of South America. It was a very enjoyable meeting and visitors carried away with them a memory of high scientific endeavour, skilfully organised surgical programmes, magnificent hotels and wonderful mountain scenery, firework displays over the lake, folk-singing over camp fires, and a general sense of the gaiety of life in Brazil.

Tribute must be paid for their tremendous effort to Dr Juan Farrill of Mexico and Dr José Bado of Uruguay who are presidents of the Latin-American Society, and to Dr Pinheiro Campos, president of the Brazilian Society, together with all those others who organised the meeting, including Professor José Valls, the honorary president of the congress and Dr Luthero Vargas, son of the president of Brazil.

INTERNATIONAL SOCIETIES

BRUSSELS TREATY ORGANISATION: PROSTHETIC SUB-COMMITTEE

AMPUTATION STUMP LENGTHS

Before the 1914–18 war there was much diversity of opinion about the best length of amputation stumps, and the old adage that most leg stumps should be end-bearing died hard. The impact of approximately 45,000 amputees in Great Britain alone, from the 1914–18 war, enabled a prolonged study of the problem to be carried out and there now appears to be a general consensus the world over, with perhaps a few exceptions, that certain lengths of stumps give better results than others both functionally and prosthetically and that what came to be termed the " ideal " stump is least liable to complications from the prolonged wear and tear of limb wearing.

At the meeting of the Prosthetic Working Party Sub-Committee of the Brussels Treaty Organisation in Utrecht from February 23–25, 1953, attended by prosthetic experts from Belgium, Britain, France, Luxembourg and the Netherlands, the following lengths of stumps were agreed as " ideal " in adult males of average height. The above-knee stump should measure 10–12 inches from the tip of the greater trochanter, and the below-knee stump 5½ inches from the medial articular surface of the head of the tibia. The Stokes-Gritti amputation was not favoured by any country, and France alone favoured the trans-metatarsal foot amputations. Foot amputations were not generally recommended; Britain was alone in favouring the modified Syme's amputation in selected cases. The Pirogoff, Chopart and Lisfranc amputations were not recommended, but the Netherlands thought that the Pirogoff and Lisfranc amputations might be considered exceptionally. No country favoured disarticulation at the hip, and Britain was alone in advocating disarticulation at the knee in selected elderly patients and in children and adolescents. The ideal upper arm stump was considered to be one measuring 8 inches from the tip of the acromion, and the forearm stump 7 inches from the tip of the olecranon. Disarticulation at the shoulder and at the elbow were not favoured by any of the countries concerned, and only the Netherlands favoured disarticulation at the wrist in special circumstances. All the countries agreed that as much sensitive and scar-free tissue as possible should be conserved in attempting to retain a functionally useful hand or part of a hand.

Greatest and least lengths of stumps were also discussed in relation to the possibility of fitting the average type of limb, and it was agreed that a femur should not be less than 6 inches or over 12 inches in length, except that Great Britain felt that the average type of limb could sometimes be fitted to stumps shorter than 6 inches. It was generally agreed that the below-knee stump

should not be shorter than 2 inches or longer than 6 inches. It was agreed that the length of a stump above the elbow should range between 1 inch below the pectoralis major tendon and 3½ inches above the elbow if the most useful type of articular arm were to be fitted and adequately controlled, and that a forearm stump should not be shorter than 3½ inches or longer than 8 inches from the tip of the olecranon—the Netherlands again advocating the retention of the through-wrist amputation exceptionally.

INTERNATIONAL SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

PROVISIONAL ARRANGEMENTS FOR THE 1954 MEETING IN BERNE, SWITZERLAND

The Sixth congress of the International Society of Orthopaedic Surgery and Traumatology will be held in Berne from August 30 to September 3, 1954, as briefly announced in the May number of the Journal. To facilitate the task of the organisers, those who intend to be present are requested to notify the secretary general (Dr Jean Delchef, Rue Montoyer 34, Brussels, Belgium) before May 31, 1954, at the latest. Active and retired members of the Society are admitted without charge to the scientific sessions. Those who are not members of the Society may participate as associate members on payment of a registration fee of 40 Swiss francs. Members of the Society will receive the reports to be presented to the congress on or before February 28, 1954. Those who wish to take part in the discussion of the reports should inform the secretary general before May 31, 1954, and should forward a summary of 250 words, preferably in English and French. Members of the Society who wish to read papers at the meeting should send to the secretary general, through their own national committee, a summary of 250 words, in English or French, before May 31, 1954. They would certify that the communication has not already been published either in substance or in form.

In due course those registered as taking part in the congress will receive a personal card (of different colour to distinguish active members, associate medical members, and associate non-medical members). Each card will have a number which will enable the holder to exchange it readily, on arrival in Berne, for his congressist's folder. This folder will contain: a congress badge; the final programme of the congress; the text of the reports; the summaries of papers and discussions; a summary of the lectures to be delivered during visits outside Berne on September 1; and a card of admission to the outside visits and to the social functions of the congress.

Those who intend to take part in the scientific programme are reminded that reports are limited to twenty minutes each, and discussions and papers to ten minutes each. This rule will be strictly enforced.

Provisional Programme

Monday, August 30—9.00: Meeting of International committee. 11.00: Official opening of congress. 14.00: First scientific meeting. The treatment of scoliosis—Reports by Professor Bryan McFarland and Mr J. E. P. James (Great Britain). 14.45: Discussion. 17.15: Departure for dinner in the Bernese countryside.

Tuesday, August 31—9.00: Further discussion on the first subject. Papers. 11.00: General assembly. 14.30 to 17.30: Papers.

Wednesday, September 1—Visits, in groups, to various Swiss medical centres. *Group* 1: **Basle.** Departure from Berne at 8.30. Visit to hospitals, with clinical demonstrations arranged by Drs Hans Debrunner and E. Burckhardt (Basle). Symposium on orthopaedic and traumatological problems in gerontology (openers Drs A. L. Vischer, R. Nissen and Hans Debrunner (Basle)). *Group* 2: **Berne-Macolin** (in the Bernese Jura). Departure from Berne at 9.00. Visit to hospitals, with clinical demonstrations, arranged by Dr Marcel Dubois (Berne). Symposium on the physiological background of maximal performances in sport (openers Dr E. Howuh Christensen (Stockholm), Dr Alex von Muralt (Berne) and Dr E. Grandjean (Zurich)). Visit to the Federal School for Gymnastics and Sports at Macolin. *Group* 3: **Geneva.** Departure from Berne at 8.45. Visit to hospitals, with clinical demonstrations by Drs A. Jentzer and A. Perrot (Geneva). Statement on the physiopathology of fractures by Dr R. Patry (Geneva). Symposium on osteoarthritis of the hip (openers Drs E. Rutishauser, P. Bardet and A. Perrot (Geneva)). *Group* 4: **Lausanne-Leysin.** Departure from Berne at 8.45. At Lausanne: Clinical demonstrations by Drs J. C. Scholder, P. Decker and L. Nicod (Lausanne). Statement on muscle degeneration and its treatment by Dr A. Fleisch. At Leysin: Visit to the clinic manufacture. Symposium on skeletal tuberculosis (openers Drs E. Sorrel (Paris), P. Gérard-Marchant (Berck) and M. Wasserfallen (Leysin)). *Group* 5: **Zurich.** Departure from Berne at 8.25. Visits to hospitals, with clinical demonstrations arranged by Dr M. R. Francillon (Zurich). Statement on the legal basis of accident surgery in Switzerland by Dr F. Lang. Symposium on the physiology and pathology of locomotion (openers Drs O. Wyss (Zurich), M. R. Francillon (Zurich) and Z. Senn (St Gallen)).

Thursday, September 2—9.00: Presentation of the second subject: Surgery of the hand—Report

of Dr Robert Merle d'Aubigné (Paris), with the collaboration of Dr L. Boehler (Vienna), Dr M. Mason (Chicago), Drs Jean Gosset and R. Tubiana (Paris), Mr R. G. Pulvertaft (Derby) and Dr J. Boyes (Los Angeles). 14.30: Discussion. Scientific papers. 18.00 to 19.00: Reception of the congressists at the French Embassy. 20.00: Banquet (by subscription).

Friday, September 3—9.00: Scientific papers. 14.30: Closing session of the congress.

Saturday, September 4—Excursions. Jungfraujoch, with visit to the Scientific Station (3·575 m.) (one day). Lake of Geneva and Valais (Zermat) (three days). The Grisons (St Moritz) (three days). Central Switzerland (Lake of Lucerne), Ticino (three days).

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CORRESPONDENCE

Radiological interpretation of Jüngling's disease and chondroma of bone—Although quarterly journals do not readily lend themselves to the vigour of correspondence columns, so that after one or two trials the British Editorial Board has discouraged such correspondence, we would like to record the comments of Dr Campbell Golding of London on two articles published in the May issue of the British volume of the *Journal of Bone and Joint Surgery* in criticism of the radiological interpretation. In reference to the paper by William Girdwood of Johannesburg* in which a case of tuberculosis of the hand and foot was described as Jüngling's disease he writes: "This was in fact tuberculous dactylitis in an adult showing trabeculated and expanded bone, from which the bacillus was identified; it is an uncommon manifestation of tuberculosis but it is not Jüngling's disease. Jüngling described osteitis tuberculosa multiplex cystoides, which bears no resemblance to this condition; he never isolated the bacilli from the lesions. I understand Jüngling's disease to be one of the synonyms for sarcoid, and similar to lupus pernio, Schaumann's lymphogranuloma, Besnier-Boeck sarcoid, or, as it is now called Boeck's sarcoid. Without correction, this article may help to perpetuate a fallacy."

Dr Golding refers also to the article by W. Laurence and E. L. Franklin† in which five cases were described as chondroma in long bones and he writes: "The case in which a biopsy was performed looks like a chondroma but the others do not. There are many cases in the literature with identical appearances which were in fact infarcts of bone. Of the cases published in this article one patient was aged fifty-three years and the other four were all over sixty years—an age when infarction may easily occur. The pathological evidence which is presented, based on degenerated cartilage, is not enough to establish the diagnosis of chondroma. I would not have quarrelled so much with the report if there had been reference to infarct of bone in the differential diagnosis; but it was not even mentioned, whereas chondroblastoma and Brodie's abscess were put forward as possibilities, both of which are slightly ridiculous—the first by reason of the age of the patients, and the second because the lesions bear no resemblance to chronic abscess."

* Girdwood, W. (1953): Multiple Cystic Tuberculosis of Bone (Jungling's Disease). Journal of Bone and Joint Surgery, **35 B,** 285.

† Laurence, W., and Franklin, E. L. (1953): Calcifying Enchondroma of Long Bones. Journal of Bone and Joint Surgery, **35 B,** 224.

Book Reviews

SURGERY OF REPAIR AS APPLIED TO HAND INJURIES. By B. K. Rask, M.S., F.R.C.S., F.R.A.C.S., Honorary Plastic Surgeon, Royal Melbourne Hospital; and A. R. Wakefield, M.S., F.R.C.S., F.R.A.C.S., Honorary Plastic Surgeon, Children's Hospital, Melbourne, Australia. With a foreword by Sir Gordon Gordon-Taylor, K.B.E., C.B., LL.D., Sc.D., F.R.C.S., F.R.C.S. (Ed.), F.R.A.C.S., F.A.C.S., F.R.C.S. (Canada). 10 × 7 in. Pp. xiv + 256, with 188 figures. Index. 1953. Edinburgh and London: E. & S. Livingstone Ltd. Price 40s.

This small volume on the treatment of acute hand injuries by two surgeons so well known in this special field of surgery is most welcome. It is essentially a practical book and does not offer much new in hand reconstruction. The role of plastic surgery in the treatment of the damaged hand has been most adequately discussed and beautifully illustrated. This book will therefore be particularly useful to orthopaedic surgeons treating the injured hand, especially the younger men who are so often called upon to deal with these cases, though it may sometimes (and wisely so) stimulate them to call in surgeons with a knowledge of this technically specialised field. The repair of tendon, nerve and bone is not so well covered, and the value of the book is limited by many gaps in the description of technical details; it would be impossible to understand the full technique of tendon grafting from the description given. Above all, this book emphasises the importance of good primary surgery. In those of us concerned with the reconstruction of the injured hand, weeks or months after the accident, a strong feeling of envy is aroused by the results, illustrated in this book, of severe hand injuries treated from the first day by these two skilled surgeons.—J. I. P. James.

COMPRESSION ARTHRODESIS including central dislocation as a principle in hip surgery. By John Charnley, F.R.C.S., Consultant Orthopaedic Surgeon to Manchester Royal Infirmary; Part-time Lecturer in Orthopaedics, University of Manchester. With a chapter on Mechanics by Professor J. A. L. Matheson and Histological Observations by Professor S. L. Baker. 10 × 7 in. Pp. xi + 264, with 208 figures. Index. 1953. Edinburgh and London: E. & S. Livingstone Ltd. Price 42s.

There must be few orthopaedic surgeons who have not already experienced the benefit to be gained from compression arthrodesis. Possibly it is to these few in particular that this book has been directed, for it leaves no doubt of its purpose, or of the intention for which it is written. Charnley has created a monograph which displays clearly the principles of union between cortical and cancellous bone surfaces during compression. He discusses fully the differentiation between the osteogenic and the osteoclastic factor of bone reaction under conditions of pressure, and applies himself to the problem of proving his claim of unusually early bone union. The crux of his argument comes from the histological examination of cores of bone removed from the line of apposition four weeks after operation. Professor S. L. Baker, who has prepared and examined the specimens, gives authoritative evidence in support of this claim. These are his comments: "The union of arthrodesis surfaces in these specimens shows the features of rapid healing of a completely immobilised fracture like that occasionally seen in an undisturbed impacted fracture, for example a Colles fracture." "The explanation of the rapid healing is clearly not rapid production of a large amount of callus. The total amount of callus is small—less than that produced in many fractures at four weeks—but conditions are such that this small amount of new bone is used to the best mechanical advantage." Professor J. A. L. Matheson writes briefly on the mechanical principles underlying the Charnley method of compressing the knee joint. In the remainder of this book Charnley describes, in their latest form, the various ingenious techniques that he has employed for compressing the rawed bone surfaces of almost any joint which an orthopaedic surgeon might be challenged to heal. Only one joint seems to have made the author hesitate—the hip. Here there has been a searching for perfection, as no less than four different operations are described, and one wonders a little how high must be his ideals when the results of the first method seem to have been so satisfactory.

Charnley has never claimed to be the first to describe the technique of compression arthrodesis; from the outset of his communications on this subject he has acknowledged the work of Albert Key, but to Charnley must go the credit of recognising its possibilities, of seeking a physiological explanation and of exploiting the appropriate methods of arthrodesing different joints. In the

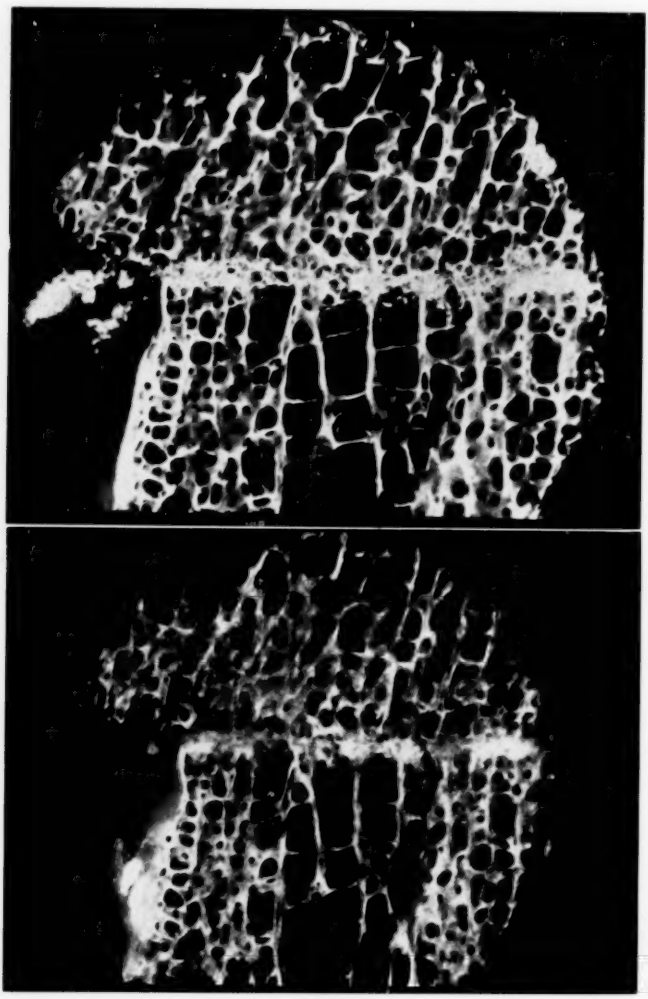

FIG. 27

(A) (*Top*) Micro-x-ray of 1 millimetre slice of undecalcified coring removed four weeks after compression arthrodesis of the knee. (B) (*Bottom*) Ordinary photograph (visible light) of same specimen after digestion with trypsin. True osseous union. (Note magnification of reproductions a little different in (A) and (B). Original disc of bone 0·75 inch in diameter.)

early chapters of this book light is thrown on the basic principles of bone healing in clear and well selected argument, whereas the second half is a practical guide for the operator. The illustrations, especially the photomicrographs and the radiomicrographs demonstrating bone union, are excellent. The whole is very well worth reading and the publication reaches the high standard of the house of Livingstone. Philip NEWMAN.

POLIOMYELITIS. Papers and Discussions Presented at the Second International Poliomyelitis Conference. Compiled and Edited for the International Poliomyelitis Congress. 10½ × 7½ in. Pp. xxi + 555, with numerous figures. Index. 1952. Philadelphia, London, Montreal: J. B. Lippincott Company. Price 60s.

This publication contains the whole of the material used in the lectures and discussions at the last international conference at Copenhagen in 1951 together with pictures and records of all the scientific exhibits. The first day of the conference was devoted to a symposium on virus and its interaction with the host cell. On the next day there was a review on the pathology of poliomyelitis, and it opened with the paper by John F. Enders on "The Multiplication and Properties of Poliomyelitis Viruses in Cultures of Human Tissue," which was received with more acclaim than any other communication during the whole conference. His discovery that poliomyelitis viruses can be propagated in non-nervous tissue culture is entirely new and shatters

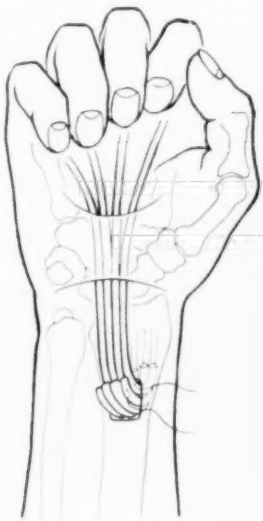

FIG. 65

FIG. 66

Figure 65.—Hendry's flexor-extensor tenodesis for complete paralysis of the hand, suitable for cases in which full passive movement of the digits has been preserved. (Illustration reduced.)
Figure 66.—A complete flail limb resulting from poliomyelitis in which a bone-block operation was performed at the elbow and a flexor tenodesis for control of the digits. An extensor tenodesis was not necessary since there was already a most convenient extensor contracture. (Illustration reduced.)

the concept that poliomyelitis virus is purely neurotropic. Then followed a symposium on the Coxsackie viruses all of which had been discovered since the First International Conference; their properties, and the clinical results of their invasion of the host, prove of great interest. On the third day a symposium on differential diagnosis included a paper by Jordi Casals on "A Specific Complement-Fixation Test for Poliomyelitis" which was made possible, after thirty-five years of failure on the part of other workers, by the new principle of using "baby mouse brain" in preparing the antigen; so serological diagnosis of the disease may soon be available. The fourth day, devoted to a review of treatment, will be of most interest to orthopaedic surgeons. The paper by James Wilson on "The Management of Respiratory Insufficiency" is particularly interesting now in the light of the experience gained from the subsequent Copenhagen epidemic of 1952 with its high incidence of bulbar and respiratory paralysis. Reconstructive surgery of the upper extremity is covered most ably by H. J. Seddon, and by Charles E. Irwin in a paper of equally high quality on "Surgical Rehabilitation of the Hand Disabled by Poliomyelitis." John Cobb on "Correction of Scoliosis" gives an excellent and authoritative account of this problem. Robert Bennett's paper on "Physical Medicine in Poliomyelitis" is most helpful in clearly emphasising the difference between the muscle spasm sometimes seen in poliomyelitis and the common tightness

of the fibrous and fibro-elastic tissues which accounts for so many contractures. The last day of the conference was devoted to a symposium on immunity and resistance in poliomyelitis and a review of the ecology of poliomyelitis. The proceedings closed with a thoughtful and wise summary by John Paul entitled "Knowledge and Trends in Poliomyelitis." In the section on scientific exhibits the book contains much of practical help to those concerned with the management of this disease.

This book is strongly recommended to everybody interested in poliomyelitis because of the value of the individual papers mentioned and because some information on every conceivable angle of the problem of poliomyelitis is accessible somewhere in this large but not cumbersome volume.—John M. P. Clark.

SYMPATHETIC CONTROL OF HUMAN BLOOD VESSELS. By H. Barcroft, M.A., M.D., M.R.C.P., Professor of Physiology, St Thomas's Hospital Medical School, London; and H. J. C. Swan, Ph.D., M.B., M.R.C.P., Research Associate, Mayo Clinic, Rochester, Minnesota. Monographs of the Physiological Society, Number 1. 8½ × 5½ in. Pp. vii + 165, with 67 figures. Index. 1953. London: Edward Arnold & Co. Price 18s.

This is the first of a series of monographs sponsored by the Physiological Society. It will be welcomed by clinicians as affording them an opportunity, without the labour of wading through the numerous journals, of keeping abreast of knowledge in a fundamental science. The orthopaedic surgeon at times performs a sympathectomy to improve the condition of the skin. Is the operation based on sound theory? The answer to this and other questions is to be sought for in a monograph such as this. It is refreshing to find that the experimental physiologist does not know all the answers, any more than the clinician does.—George Perkins.

ACUTE PERIPHERAL ARTERIAL OCCLUSION. By William D. Holden, M.D., Oliver H. Payne Professor of Surgery, Western Reserve University School of Medicine; Director of Surgery, University Hospitals of Cleveland, Ohio. 8½ × 5½ in. Pp. vii + 66, with 2 figures. Index. 1952. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. Price 17s. 6d.

This short monograph is No. 141 in the American Lecture Series being published for the Cleveland School. It deals briefly with arterial obstruction by injury, by embolism and by thrombosis, and the author relies more upon his own experience than upon the literature when he draws his conclusions. He gives a vigorous defence of embolectomy in the peripheral arteries, and he accepts the possibility of neurogenic arterial spasm. He describes one case of carotid embolism, alas without post-mortem or operation. He writes interestingly, and has added another creditable booklet to this valuable series.—D. Ll. Griffiths.

DIE KONSERVIERUNG VON KNOCHENGEWEBE FUR TRANSPLANTATIONEN. By Hans Roth. 10 × 7 in. Pp. vi + 222, with 147 figures. Index. 1952. Vienna: Springer-Verlag. Price £4, 3s.

A number of factors contribute to the present interest in basic studies on bone grafting. Amongst these are the frequent clinical use of bone grafts, the stimulus provided by studies on the transplantation of a variety of other tissues, such as skin, cornea, blood vessels, endocrine glands, and even kidney, and the development of synthetic materials such as plastics as possible alternatives to bone as a grafting material. Despite the numerous papers appearing on clinical and experimental aspects of bone transplantation and related topics, there is as yet no comprehensive general review of the subject, and those wishing to gain general knowledge of the field must find their way through a maze of unco-ordinated and often conflicting contributions. To those familiar with German, the present volume, written by a surgeon of the University clinic at Basle, provides at least a partial answer to this very real need. Not only does it discuss methods for the preservation of bone tissue for transplantation, but it gives a good general account of the behaviour of bone transplants as seen in clinical and experimental studies. The author summarises most of the important work in this field, and describes, in addition, experimental work of his own. He also recounts his extensive clinical experience with bone grafts, and with the organisation of a "bone bank" for the preservation and storage of the necessary grafting material.

Dr Roth's own experimental data, as well as his summary of the work of others, serves as a reminder that the function of a bone graft is quite different from that of most other tissue transplants. The ultimate fate of a satisfactory bone graft is to be completely replaced by living bone derived from the host tissue surrounding it. With most other transplants, the actual survival of the grafted material itself is necessary for success. It is because of this difference, of course, that bone grafts transplanted from one individual to another of the same species (a "homograft"), or even from one species to another (a "heterograft"), can be effective, although in these circumstances no survival of the transplanted cells is possible. Indeed, even with bone transplanted from one part to another of the same individual (an "autograft"), it is found that virtually all the cells die because of interference with the vascular supply of the transplanted tissues, and in this case, too, the graft "heals in" by invasion from host tissues. In fact the success or failure of a bone transplant is not dependent on the survival of its cells, but on its effectiveness as a temporary "scaffolding," and on any influence it may have as a chemical stimulus to the development of new bone by the metaplasia of the host tissue in contact with it. For this reason, Roth points out, the effectiveness of a particular type of bone graft, or that of a particular method of bone preservation, should be judged, not by the survival of bone cells in the graft, but by evidence relating to the "biological specificity" of the graft, and—particularly—to the stimulus to bone formation that it provides. He comments that the final assessment of various types of bone graft, and of various methods of bone preservation, either in experimental or clinical studies, has yet to be made. General clinical opinion, however, favours autografts as superior to homografts, and still more so to heterografts. Roth's own opinion on this point is that present day ability to counteract infection with antibiotics and chemo-therapeutic agents, together with knowledge of favourable mechanical conditions for grafting, make it possible for properly preserved homograft bone to be employed with just as good final results as autografts, even if the "healing" of the grafted bone occurs somewhat more slowly. At the same time, he stresses that the actual decision regarding the type of transplant to be used in any particular case must be an individual one influenced by all the factors concerned.

Dr Roth reviews the various techniques that have been developed for the operation of a "bone bank," and describes fully the procedures he himself employs for obtaining and storing bone for grafting. He uses corpse bone, removed with aseptic precautions, and—on the basis of the experimental studies described elsewhere in the book—preserved by refrigeration in liquid paraffin at a temperature of about −15 degrees Centigrade. He has used such material on more than 100 occasions, in a wide variety of operations, particularly arthrodeses, spinal fusions and the repair of ununited fractures. The results of this clinical work are presented in detail.

The book is written from the very personal viewpoint of the author's experience, and does not profess to be a complete account of all aspects of bone transplantation. But it presents this subject in a lively fashion as a technique awaiting further development through systematic experimental and clinical work, and not as a procedure whose uses and methods have been established finally. It is of particular interest to find that Dr Roth considers the clinical use of preserved bone as something which should be employed "only by those who are prepared at the same time to work in collaboration experimentally and clinically for the further development of the method." He is thus opposed to the operation of centralised "bone donor centres," and considers that the dual responsibilities involved, *i.e.*, the removal and preservation of bone, on the one hand, and the clinical use of such material, on the other, should not be divided. The book is accurately written and excellently produced, with an index and a good bibliography. It will be welcomed, not only by orthopaedic surgeons, but by all those concerned with clinical and experimental aspects of bone transplantation.—H. A. Sissons.

POSTURE AND PAIN. By Henry O. Kendall, Director; Florence P. Kendall, Assistant Director; and Dorothy A. Boynton, Physical Therapist, Physical Therapy Department, Children's Hospital School, Baltimore, Maryland. 11 × 8½ in. Pp. viii + 204, with 159 figures. Index. 1952. London: Baillière, Tindall & Cox Ltd. Price 54s.

There is much of value in this book, the fruit of a unique experience of problems connected with posture. It is profusely illustrated with excellent photographs and line drawings, which not only make the text clear but also show the care with which the authors study each patient. The section about the various types of postural defect contains a mechanical analysis that will be specially helpful to therapists. The physiological basis is, however, very much that of the old school, and one cannot help wondering whether the undoubted practical success achieved by the Kendalls is not due as much to their personalities as to the particular methods of treatment advocated.—Philip Wiles.

AN ATLAS OF SURGICAL EXPOSURES OF THE EXTREMITIES. By Sam W. Banks, M.D., Associate Professor of Orthopaedic Surgery, Northwestern University Medical School; Attending Orthopaedic Surgeon, Chicago Memorial Hospital and Woodlawn Hospital; and Harold Laufman, M.D., Ph.D., Associate Professor of Surgery and Director of Experimental Surgery, Northwestern University Medical School; Associate Attending Surgeon, Michael Reese Hospital. $10\frac{3}{4} \times 7\frac{3}{4}$ in. Pp. xviii + 391, with 552 figures in 179 plates. Index. 1953. Philadelphia and London: W. B. Saunders Company. Price 75s.

This is a spacious and beautiful work. The illustrations, mostly by Miss Jean McConnell of Northwestern University Medical School, are a fine example of the excellent medical draughtsmanship of North America. They lose little by being uncoloured. The arrangement is ideal, the stages of each operation being illustrated on the right-hand page with a corresponding reasonably clear and concise description opposite.

It would be wrong to look to an atlas for guidance about choice of procedure or details of technique. These subjects are already dealt with elsewhere. The authors only occasionally touch upon them, but they do include, in small print, indications for each exposure. Anyone who has tried to do the same knows that pitfalls are inevitable; but surely it is unwise to suggest that the simple, straight, anterior approach to the hip is suitable for open reduction of congenital dislocation, and surely no one now treats recurrent dislocation of the shoulder by tenodesis of the biceps.

One of the most striking things about this book is its comprehensiveness. This is both its strength and its weakness. Every orthopaedic surgeon must be master of all the ordinary approaches, but this book will remind him that there are others that may exceptionally serve better, and will help him in planning exceptional operations that call for exceptional approaches. For the junior, the ordinary approaches are too much obscured by a multitude of others that he is much safer without—for instance, exposure of the ulna from the front, or an approach to the elbow by removing the medial epicondyle. We therefore read with surprise that "This pictorial atlas is designed to serve the *student and resident in surgery* as an *introduction* to the *most frequently used* exposures of the extremities, and to be a timely 'refresher' to the *experienced surgeon who operates on the extremities only occasionally*" (the italics are the reviewer's). These are just the folk whose discrimination may not be equal to so rich and varied a feast. Above all, we hope it will escape the omnivorous attention of undiscerning examiners.

This becoming book is the outcome of the great, able and well organised labour of many—notably of the authors, artists and publishers. They can justly feel that they have given orthopaedics a work of great and lasting value.—H. Jackson Burrows.

NON-PULMONARY TUBERCULOSIS OF BOVINE ORIGIN IN GREAT BRITAIN AND NORTHERN IRELAND. By Graham Selby Wilson, M.D., F.R.C.P., M.R.C.S., D.P.H., Director, Public Health Laboratory Service, Medical Research Council; John William Stewart Blacklock, M.D., F.F.P.S., Professor in Pathology, St. Bartholomew's Hospital Medical College, London; and Lilian Violet Reilly, B.Sc., M.D., D.P.H., Bacteriologist to the Northern Ireland Tuberculosis Authority. $9 \times 5\frac{1}{2}$ in. Pp. 107, with 48 tables. 1952. London: The National Association for the Prevention of Tuberculosis. Price 16s.

In many respects this is a disappointing book, though the faults do not lie with the authors. A committee appointed by the Medical Research Council in 1941 to investigate the extent and increase in the death rate from tuberculosis in England and in Wales issued its report in 1942. This was published in 1949, and is reproduced here. Another committee was appointed to make a similar investigation in Scotland and though this covered the years 1943 and 1944, its report appears in this book for the first time. Finally there is reproduced the survey, published in 1950, of the bovine-type tuberculosis in Northern Ireland during the years 1945–1950. Because of differences in the methods of carrying out the enquiries, and for other reasons, it has not been possible to make a comparison of the results obtained in the four countries. In addition to bringing the reports together in one volume, the authors have provided a general discussion of the English, Welsh and Scottish reports.

In non-pulmonary tuberculosis (meningeal and surgical) 26·3 per cent of the strains in England, 17 per cent in Wales and 21·7 per cent in Scotland were bovine. In Northern Ireland only 4·3 per cent were bovine, but there was a far higher proportion of meningeal cases than were investigated in England or Scotland.

Bovine-type infections were found to be most frequent in the second quinquennium of life.

Greater attention to infant feeding has reduced the incidence during early childhood, but the authors suggest that the Milk in Schools Scheme may be responsible for some of the infection of school children as "there is still an appreciable proportion of milk consumed raw under the Scheme, particularly in small towns and country districts." Approximately 30 per cent of cases in England and Wales occurred in persons over fifteen years of age, from which the conclusion is drawn that "it is unwise to drink raw milk at any age." In England the proportion of bovine infections in females over fifteen years of age was nearly double that of males of the same age group. This was not supported by the figures from Wales or Scotland, and there are no details of sex-age distribution of bovine tuberculosis in the Northern Ireland report.

It was found that in England the proportion of dairy herds yielding tuberculous milk—6·9 per cent—was nearly as high in 1936–44 as it had been twenty years earlier, and it is calculated that about 1,300 persons died in England in 1944 from non-pulmonary tuberculosis of bovine origin. In England only 5·4 per cent of herds were attested, whereas in Wales this figure is 21·3 per cent and the proportion of bovine-type infections is lower. The marked decline of bovine-type infection in Northern Ireland is attributed to the great increase in pasteurisation of milk rather than to the reduction of tuberculous cows.

It is impossible to say what changes have occurred in Great Britain in the ten years since these reports were written.—C. H. Lack.

LÉSIONS NOUVELLES DU POIGNET. By Jean-Pierre Bugnion. 10 × 7 in. Pp. 123, with 47 figures. 1951. Stockholm: Acta Radiologica, Supplement 90. Price Sw. kr. 20.

"In form and in purpose this work is a doctorate thesis, and the luxurious trappings of a supplement to the *Acta radiologica* cannot disguise the fact that its content is neither more nor less weighty than is that of the average thesis. The title is misleading, for focal rarefactions in the carpal bones have long been the subject of casual observation and comment by radiologists, and new names and new theories do not make new diseases. The lesions have generally been unassociated with clinical symptoms, and their genuine unimportance is rather underlined by the author's detecting their presence, by post-mortem radiography, in one or both wrists of about 60 per cent of 300 unselected cadavers coming to necropsy in Geneva. Cysts were demonstrated most commonly in the capitate and lunate bones, sometimes in several bones in the one carpus. They seemed to be unrelated either to sex or to occupation, but their incidence increased with age at death. Histological examinations were made of eighteen affected wrist joints. The findings are well illustrated by photomicrographs and radiographs. The author distinguishes three forms of lesions, all of which appear in the radiograph as small cysts: first, a herniation of synovial or capsular soft tissues into bone; second, a "necrobiotic pseudocyst," found especially in the aged and thought to be the consequence of vascular occlusion; third, a "marginal arthrotic form," the nosological position of which is still unsolved.

Little attempt is made to view these local findings against a background of general bone pathology or to compare them with the changes that take place in juxta-articular bone elsewhere. The conclusions are of some academic interest but of little practical importance.—Douglas H. Collins.

THE CALCULATION OF INDUSTRIAL DISABILITIES OF THE EXTREMITIES. By Carl O. Rice, M.D., M.S., Ph.D., F.A.C.S. Clinical Associate Professor of Surgery, University of Minnesota Medical School, Surgical Staff, St Barnabas Hospital, Minneapolis, Minnesota. Drawings by Jean E. Hirsch. 10 × 7 in. Pp. xv + 284, with 204 figures. Index. 1952. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. Price 77s. 6d.

This ambitious volume shows the range of movement in every joint of the extremities in line drawings, indicating the method of measurement. The author contends that the percentage loss of movement in a joint represents the disability. A formula is given with which this loss of movement is converted to a percentage disability of the whole limb which can then be related to the man as a whole. No account is taken of the loss of power in a limb, the author professing that this is taken care of in his formula. This is a view with which many people would disagree. The difficult problem of relating disability to the man's work is not taken into account deliberately—nor could it be in a volume of this type. The Courts of Common Law in this country do take this aspect of the case into their considerations, and, whilst it is the Judge who assesses damages, the surgeon should have sufficient first hand knowledge of the man's job to be able to offer some advice in this direction. In the case of National Insurance benefits, cases have to be assessed for loss of faculty, and this book would provide a useful reference for this purpose. Rice

shows that a serious attempt should be made to measure ranges of movement accurately, and that it provides a useful, though perhaps not complete, method of assessing disability in a limb. Any surgeon who is called upon to estimate disability would find it a useful book of reference.—R. A. TREVETHICK.

THERAPEUTIC USE OF POOLS AND TANKS. By Charles L. LOWMAN, M.D., D.Sc., F.A.C.S., F.A.A.P.E., Director of Education and Rehabilitation; and Susan G. ROEN, Director of Physical Therapy, Orthopaedic Hospital, Los Angeles. 11 × 8 in. Pp. xiii + 90, with 196 diagrammatic illustrations. Index. 1952. Philadelphia and London: W. B. Saunders Company. Price 15s.

This manual records in a novel manner the results of twenty-seven years' experience in the therapeutic use of water. Although most of the book is devoted to a description of exercise routines, the possibility of tedium is avoided by the excellence and simplicity of the 196 line drawings, which occupy as much space as the text. It is gratifying to find that the accent is on active effort by the patient. Particular attention is paid to the techniques of value in severe disabilities, especially poliomyelitis, paraplegia and cerebral palsy. The disadvantages of re-education in water over other methods is stressed, especially in those cases where increased muscular effort is required before full weight bearing can be permitted or is possible without appliances. To those who are fortunate in having a pool or tank at their disposal, the chapter on equipment and appliances for use in water will be valuable. To those less fortunate who may have an opportunity for extending their facilities, the chapter on construction and maintenance will appeal. Finally the appendix reproduces plans, developed by the American Physical Therapy Association and the National Foundation for Infantile Paralysis. The pool described can be easily and economically constructed, and occupies the least space compatible with complete underwater treatment. For those who are hoping to add a pool or tank to their existing facilities, this plan is well worth studying in conjunction with those available through the Ministry of Health. This concise manual presents the combined contributions of many minds and will interest orthopaedic surgeons, physical medicine specialists, and teachers and students of physiotherapy.—E. F. MASON.

ROENTGEN DIAGNOSTICS. By H. R. SCHINZ, Director, Roentgen Diagnostic Central Institute and Radiotherapeutic Clinic and Polyclinic, University of Zurich; W. E. BAENSCH, M.D., Professor of Radiology, Georgetown University, Medical School, Washington, D.C.; E. FRIEDL, Senior Assistant, Roentgen Diagnostic Central Institute, University of Zurich; and E. UEHLINGER, Director, Institute of Pathology, Cantonal Hospital, St Gallen, Switzerland. Volume II. Skeleton (Part II). Based on the fifth German edition revised and enlarged. English translation arranged by James T. CASE, M.D., D.M.R.E., Chicago. 11 × 8½ in. Pp. xiii + 1,191, with 1,500 figures. Index to Volumes I and II. 1952. London: William Heinemann Medical Books Limited. Price £15.

The first volume of the English translation of *Lehrbuch der Rontgendiagnostic*, a publication from Switzerland which is already world famed through five editions in German, has already been reviewed in this Journal, high tribute having been paid to the "immense store of accumulated knowledge." Dr J. T. Case, Emeritus Professor of Radiology at the Northwestern University Medical School of Chicago, who with his team has accepted the duties of translation did indeed accept a "labor of love" in trying to add to the translation, and the many thousands of references, those others that reflected credit to American and English workers. Nevertheless in looking through the first and second volumes we must wonder whether it was the principal author, Professor H. R. Schinz, who was responsible for the apparent piracy and plagiarism that seem to characterise this publication—more of this later.

We should first point out that this is only the second of five volumes, itself extending to more than a thousand pages and it might be wondered how so many pages could possibly be expended on one part of the radiographic study of the skeleton. There are two answers. The first rests on its verbosity. On page 1,288 it is proposed that a dislocated shoulder should be x-rayed, which seems fairly obvious; but what is written is: "We now maintain that an exact diagnosis demands above all a technically incontestible roentgenographic study." Well, really; now we know!

On page 1,061 it is noted that "pes calcaneus is characterised by the steeply tilted position of the calcaneus in the sense of maximal dorsiflexion. This is incontestibly recognisable upon the roentgenogram." All we can add is that to be incontestibly recognisable is remarkably reconcilable—but perhaps we should be kinder to those who have accepted a heavy duty of translation, and not complain too much that the one thousand pages could easily have been reduced to about five hundred.

The second reason for the amazing length and multiplicity of pages is that the volume is not concerned with radio-diagnostics alone; an attempt has been made to present a rather superficial review of the whole of surgery and medicine. When the authors confine themselves to the problems of radio-diagnosis they are good; but when they do not, they are far from good. For example orthopaedic surgeons will be disturbed to read on page 1,056 relating to congenital pseudarthrosis of the tibia that it is "therapeutically a *noli me tangere* because the incurable pseudarthrosis recurs in spite of bone transplants and eventually an amputation of the leg becomes necessary." On the subject of hallux valgus it is written: "As a result of shortening of the muscles the deformities acquire a permanent character. Under these conditions a correction is possible only by surgical shortening of the first and fifth metatarsals." For the radio-diagnostician that seems to be the beginning and the end of the treatment of hallux valgus. Why put it in at all?

Such diversion might not matter if the radio-diagnosticians really applied themselves to radio-diagnosis, but it must be noted that in this dissertation on flat foot there is no reference at all to the technique by which calcaneo-talar or calcaneo-navicular fusions may be displayed; and standing x-rays of the flat foot are not even mentioned. All that we are told is that "the inner arch of the foot is depressed and in severe cases becomes concave toward the planta." What does that mean?

We are told that "protusio acetabuli is a symptom complex which develops from the most varied morbid changes but which produces a rather simple clinical picture because it takes place in the hip joint." Where else could it take place except in the hip joint—and why does that make it simple?

On page 1,067 it is recorded that "after some gymnastic exercises by girls, or after traumatism to the arm while straightened at the elbow, partial detachment of the lateral articular ligaments from the epicondyles occurs, whereby the medial lateral ligament is more affected than the corresponding external structure; the physiologic cubitus valgus becomes accentuated." Do you understand? I don't.

We do not hesitate to pay tribute to the work that has been put into the preparation of these volumes and to the wonderful series of radiographs that have been reproduced. There is outstanding success in the recording of primary and metatastic bone tumours, skeletal malformation, bone reactions to vitamin deficiency, bone responses to hormonal disturbance, joint injuries, and disorders of the vertebral column and all the other skeletal derangements which are reviewed in such detail.

But at the same time we must protest that the authors, or perhaps the translators, have descended to the level of employing photographers to copy illustrations from many standard surgical works, reproducing them possibly without permission and expecting that sufficient acknowledgment is paid by adding to the legend: according to Hirsch, according to Schweller, according to Erdheim, according to Geschickter and Copeland; after Linblom, after Braus, after Schaer; from Key and Conwell, from Brockbank and Griffiths, from Smillie; after Watson-Jones, according to Watson-Jones—and so on for nearly half the total of their illustrations. I know for a fact that two or three score of illustrations have been photographed and reproduced from my own book without permission, and it seems quite likely that they have pirated the world.

The merit of this English translation of a world-renowned publication is acknowledged. In some respects it is superb. But it seems a tragedy that so famous a text should have become a hotch-potch of plagiarism.—R. Watson-Jones.

THE RADIOLOGY OF BONES AND JOINTS. An Introduction to the Study of Tumours and other Diseases of Bone. By James F. Brailsford, M.D., Ph.D., F.R.C.P., F.I.C.S. (Hon.), Hunterian Professor, Royal College of Surgeons of England, 1934-35, 1943-44; Founder and First President of the British Association of Radiologists (now the Faculty of Radiologists); Emeritus Director of Radiological Studies in Living Anatomy, the University of Birmingham. Fifth edition. 10 × 8 in. Pp. xv + 875, with over 725 figures. Index. 1953. London: J. & A. Churchill Ltd. Price 90s.

This monumental work expresses the zeal and industry of the author. He has been for many years an enthusiastic collector of radiographs, and naturally the collection is worth seeing. The author, however, is not content with showing radiographs. He describes the symptoms, signs and treatment of the diseases he illustrates and even puts forward his own views on pathology. All this could with advantage be omitted, for it is better done in other works and by clinicians and pathologists rather than by a radiologist. Descriptions of radiographs cannot be anything but dry, yet surprisingly this book is interesting to read. It is pleasantly written and the forcible personality of the author peers through its pages. Moreover the author's interpretation of a bone

radiograph is unexcelled, certainly in England, probably in the world. Even at its price it is worth buying. This fifth edition will doubtless be followed by a sixth, from which it is hoped the author will ruthlessly delete all indistinct, and therefore useless, pictures (Figs. 288a and 288b for example).—George PERKINS.

JOHN ABERNETHY: A BIOGRAPHY. By John L. THORNTON, A.L.A., Librarian, St Bartholomew's Hospital Medical College. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 184, with 8 plates and 5 figures. Bibliography. Appendices. Index. 1953. London: Simpkin Marshall Ltd. Price 25s.

Abernethy is remembered as the virtual founder of the medical school of St Bartholomew's Hospital and as a picturesque but rude eccentric. His real personality is elusive, and his biographical material is small, but Mr Thornton has been able to find some new sources and has pieced together impassionately a most readable narrative from which an unexpectedly pleasant picture of the man emerges.

Abernethy's masters were William Blizard of the London Hospital, Percivall Pott, to whom he was dresser at Bart's, and John Hunter of St George's. Abernethy served Bart's, not only as assistant surgeon for twenty-eight years and as surgeon for twelve, but also as lecturer in anatomy and in surgery. His ligation of the external iliac artery, probably his biggest contribution to surgery, was described in this Journal two years ago (Vol. 33-B, page 639). His emphasis on pathology and the constitutional causes of local affections, and on not merely local but general treatment, whose importance was then little recognised, is witnessed by "my book," *Surgical Observations on the Constitutional Origin and Treatment of Local Diseases; and on Aneurisms*; patients seen at Bedford Row were enjoined to buy it and follow the directions on specified pages. He excelled at teaching, and put it before all else. He had a remarkable, almost freak, memory, and, in spite of early battles with nervousness, he became the greatest medical teacher of his time—clear, incisive, practical and arresting. He was impressive, though small of stature and droll in manner, and he held attention in spite of a comfortless amphitheatre in which "each ascending row of students received the knees of those above into their backs." His well known remark at the beginning of one session: "Good God! What will become of you all?" might well be uttered to-day. In 1795 he founded the Medical and Philosophical (now the Abernethian) Society, parent, through his energy, of the St Bartholomew's Medical College Library. In 1828 he and Edward Stanley gave their pathological teaching collection of several thousands of specimens to the Hospital for the students.

In spite of Abernethy's great influence upon students, he seems to have had few close disciples: Lawrence and Skey are well known; John Haddy James, Abernethy's house pupil for some years, is written about in this number by Mr Rocyn Jones; Richard Owen began as Abernethy's prosector and came to the Royal College of Surgeons through his recommendation.

When, at length, elected full surgeon to the Hospital, Abernethy most disinterestedly petitioned the Governors that surgeons should retire at sixty, a proposal in the cause of younger men that was postponed for two centuries. To the really ill he was kindness itself, to the needy most generous. He had sensibility, and it is hard to understand his proverbial rudeness, even allowing that this honest, disinterested man, scornful of riches and rank, bound up in his hospital and teaching, grudged time given to the pretentious and frivolous. Some light is shed by the assertion of a former school-fellow, who detected but one fault—"he was rather hasty and impetuous in his manner, but it was soon over and forgotten"—and in a letter to a daughter: "Why have all the legitimate children of John Bull an aversion to politeness? 'Tis because it so commonly covereth a multitude of sins; because, with honest simplicity, they have often caught hold of the garb and found that it concealed deformity and malice. I frankly acknowledge that I may have carried my detestation too far . . ."

When Abernethy retired from the post of surgeon at Bart's, the Governors, departing from custom, declined to make him a Governor, because he was still a Lecturer. After a battle, they withdrew handsomely, and ordered "that a green staff be sent him conformable to ancient custom." The "ancient custom" continues to this day, each new Governor being presented with a green staff of office emblazoned with the arms of the Hospital.

Abernethy was elected a Fellow of the Royal Society, and held many offices at the then Royal College of Surgeons in London, including that of President. He was instrumental in founding and became President of the Royal Medical and Chirurgical Society, the parent of the Royal Society of Medicine. He declined a baronetcy. He was not of the party when Sir Astley Cooper, with six distinguished assistants, successfully removed a wen from the Royal scalp.

This book will attract others besides Bart's men.—H. Jackson BURROWS.

BOOKS RECEIVED

These books are acknowledged with grateful thanks. Selections will be made for review as space permits and in accordance with their interest for our readers.

TUBERCULOSIS OF BONE AND JOINT. By G. R. Girdlestone and E. W. Somerville, M.B., F.R.C.S. (Ed.). Second edition. 1952. London, New York, Toronto: Geoffrey Cumberlege.

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ACKNOWLEDGMENTS

We acknowledge with thanks receipt of:

Acta Chirurgica Scandinavica, and Supplements
Acta Ortopedica-Traumatologica Iberica
Annals of the Royal College of Surgeons of England
Archives of Surgery
Australian and New Zealand Journal of Surgery
Boletin de la Sociedad de Cirugia del Uruguay
British Journal of Surgery
British Medical Bulletin
Journal of Neurology, Neurosurgery and Psychiatry
Journal of the American Medical Association
Lancet
Ortopedia e Traumatologia dell 'Apparato Motore
Radiology
Revista de Ortopedia y Traumatologia
Revue de Chirurgie Orthopédique
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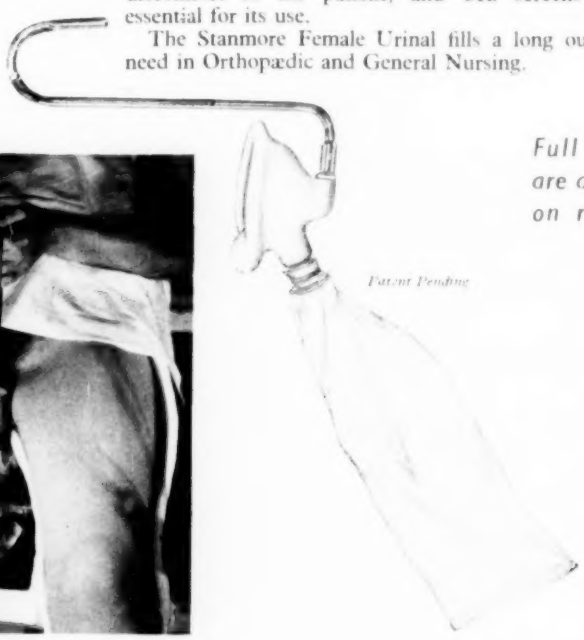

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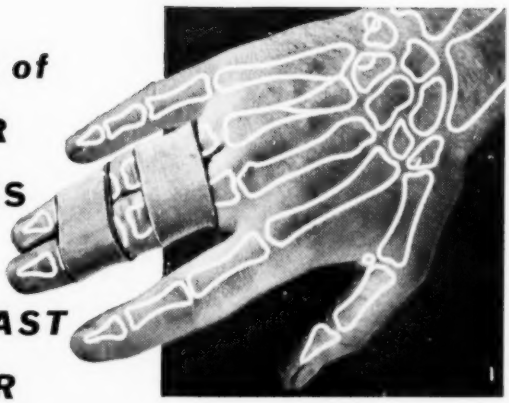

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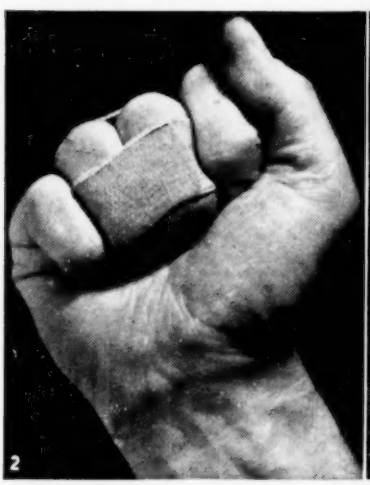

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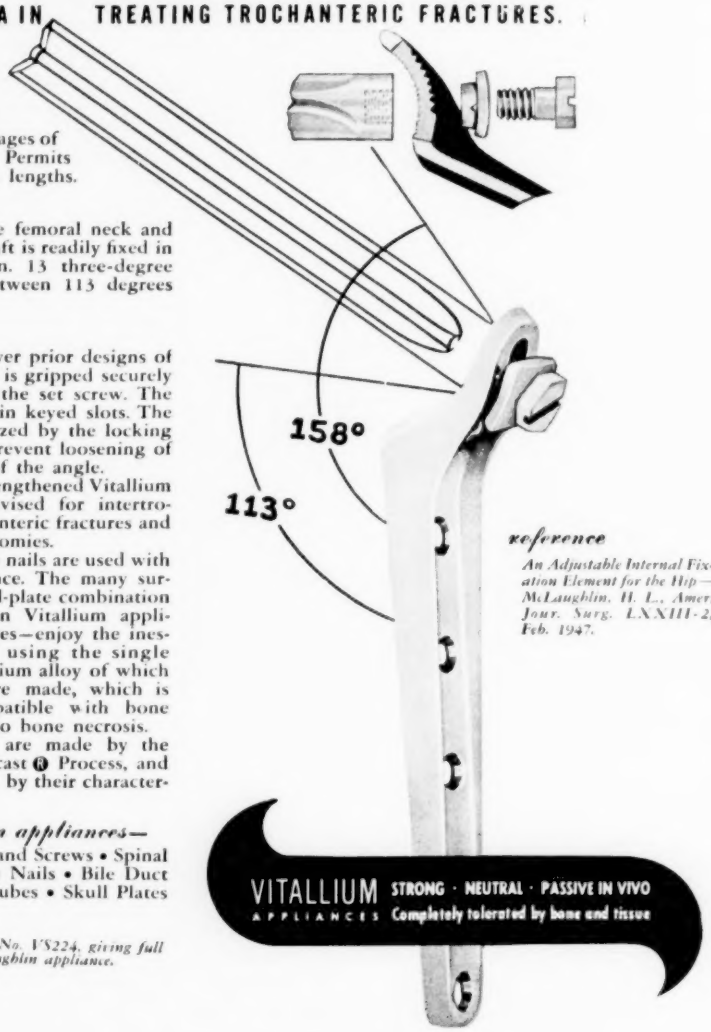

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An Adjustable Internal Fixation Element for the Hip — McLaughlin, H. L., Amer. Jour. Surg. LXXIII-2, Feb. 1947.

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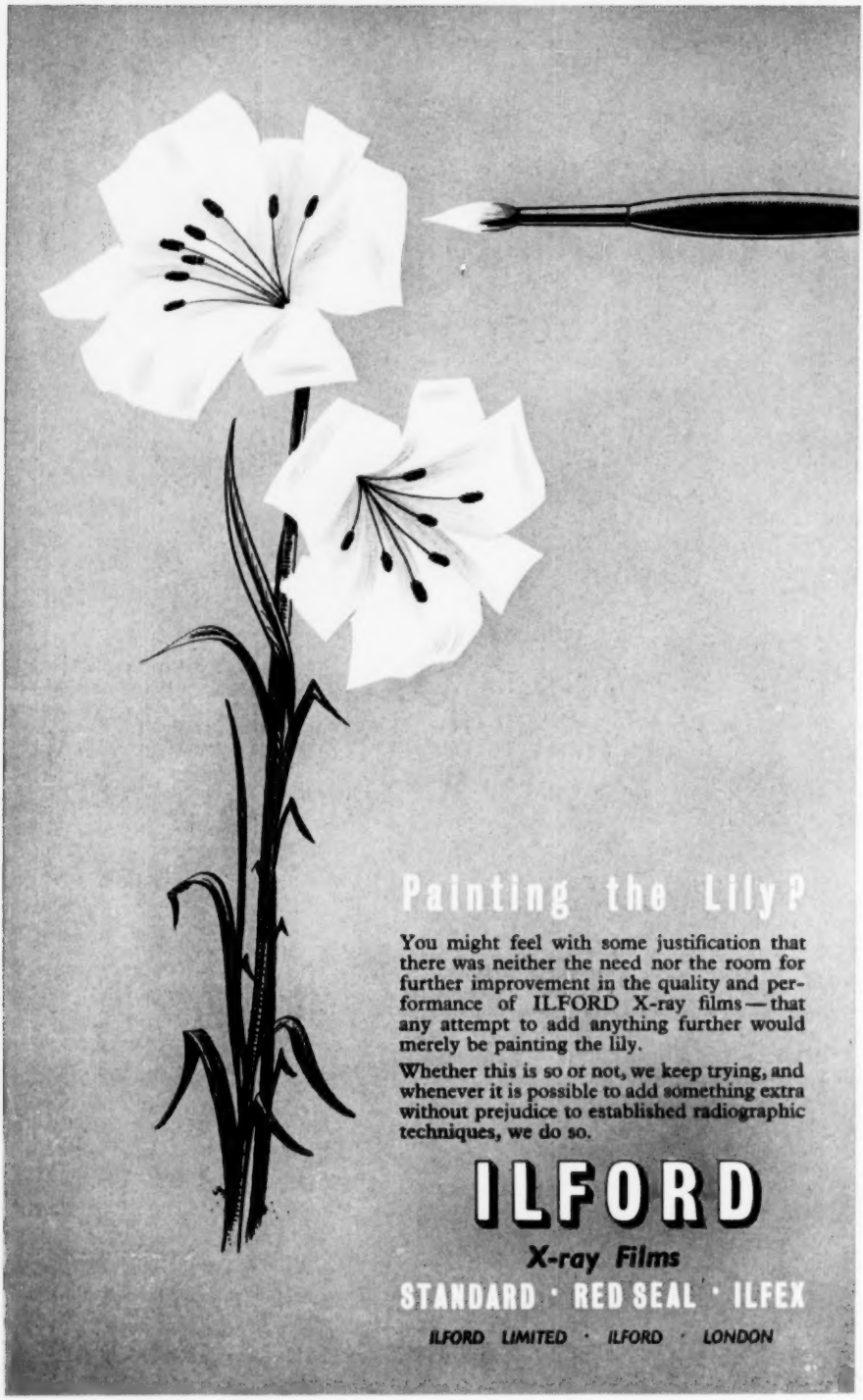
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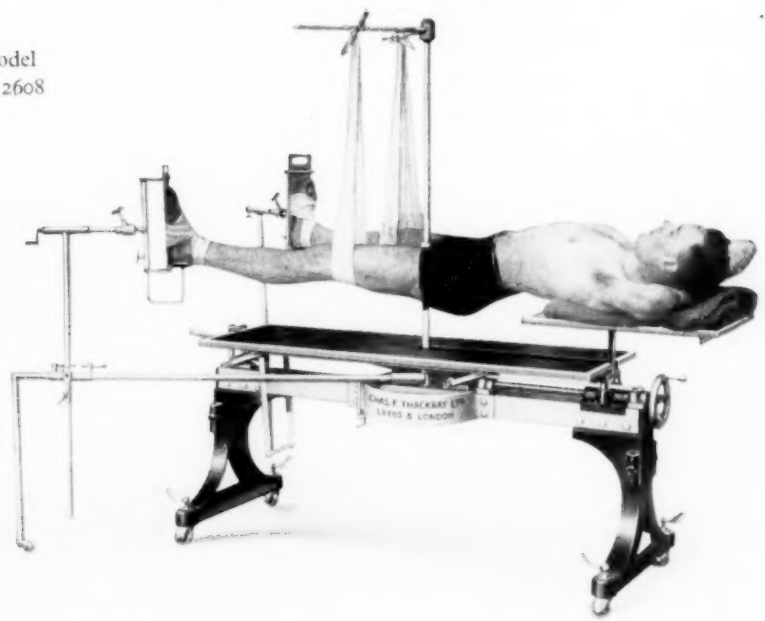

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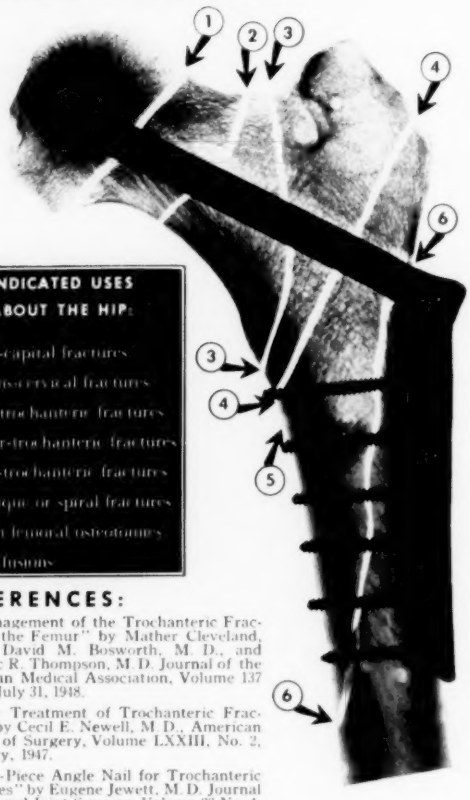

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5. "Introchanteric Fractures of the Femur" by Mather Cleveland, M.D., David M. Bosworth, M. D. and Frederic R. Thompson, M.D. The Journal of Bone and Joint Surgery, Volume 29 No. 4, October, 1947.

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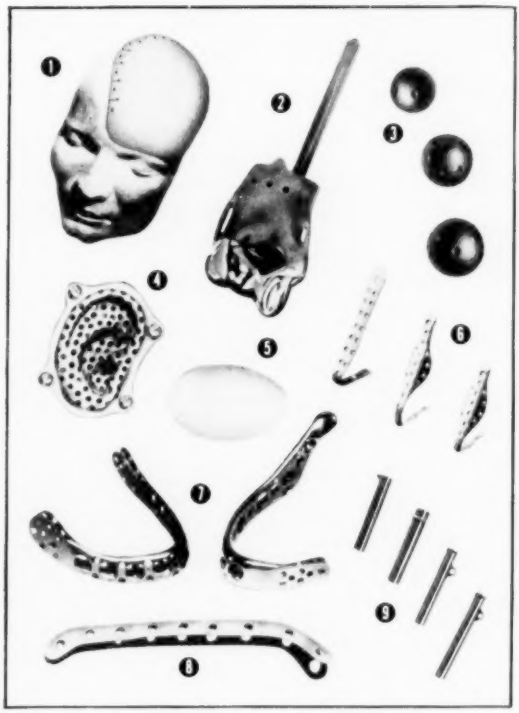

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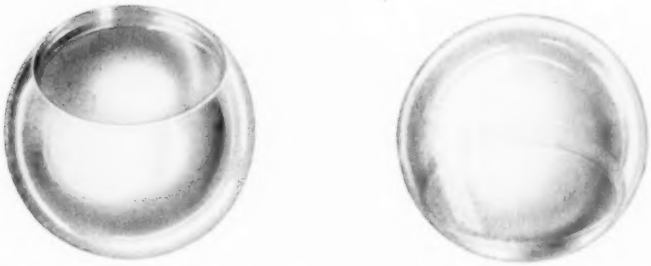

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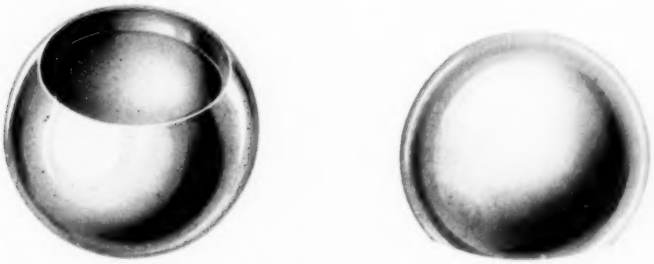

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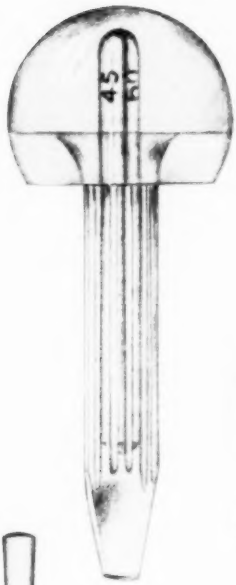

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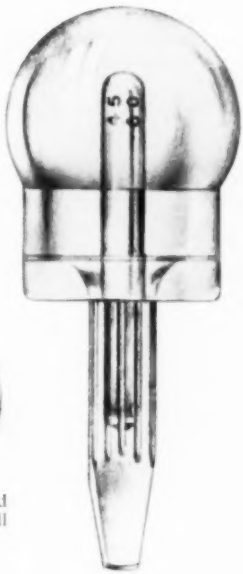

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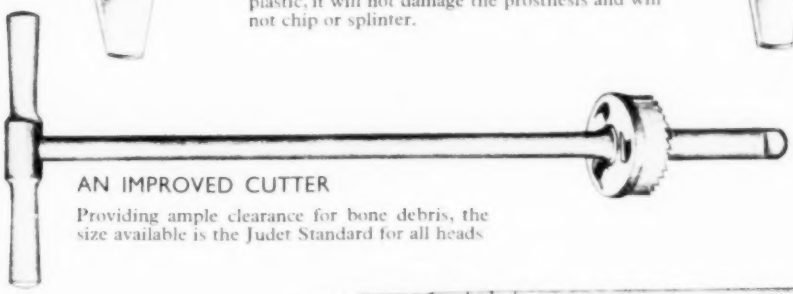

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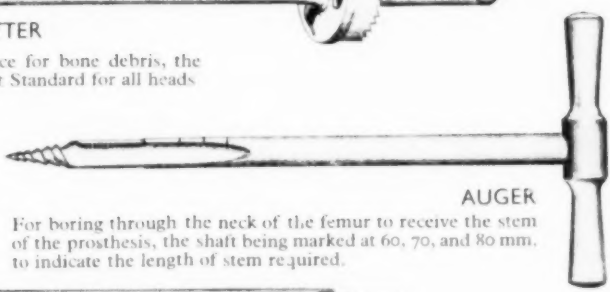

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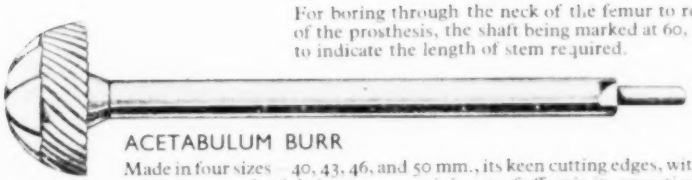

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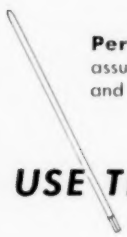

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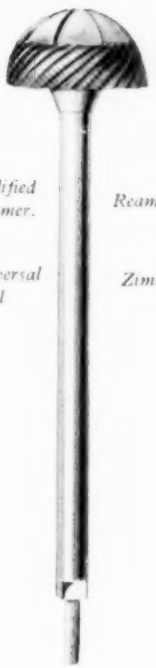

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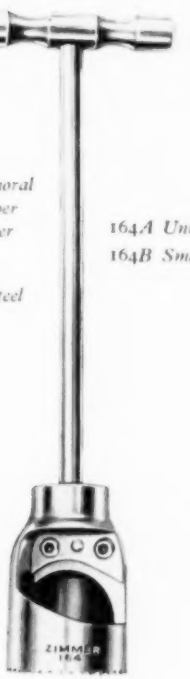

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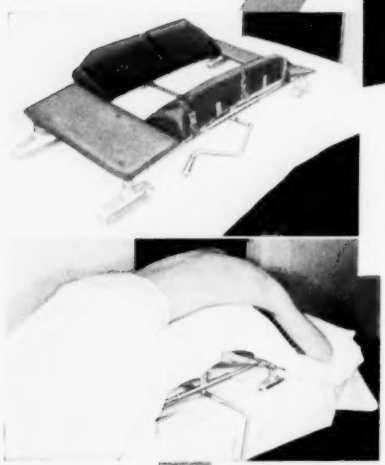

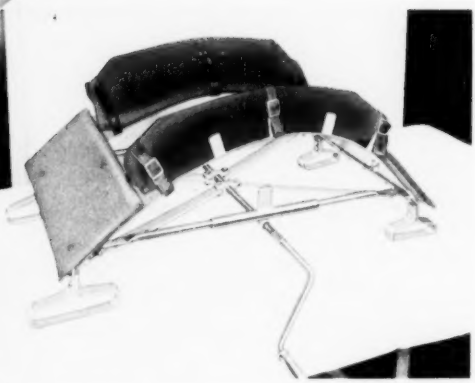

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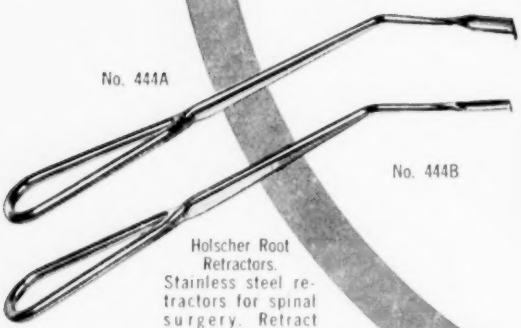

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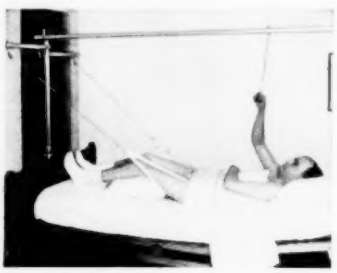

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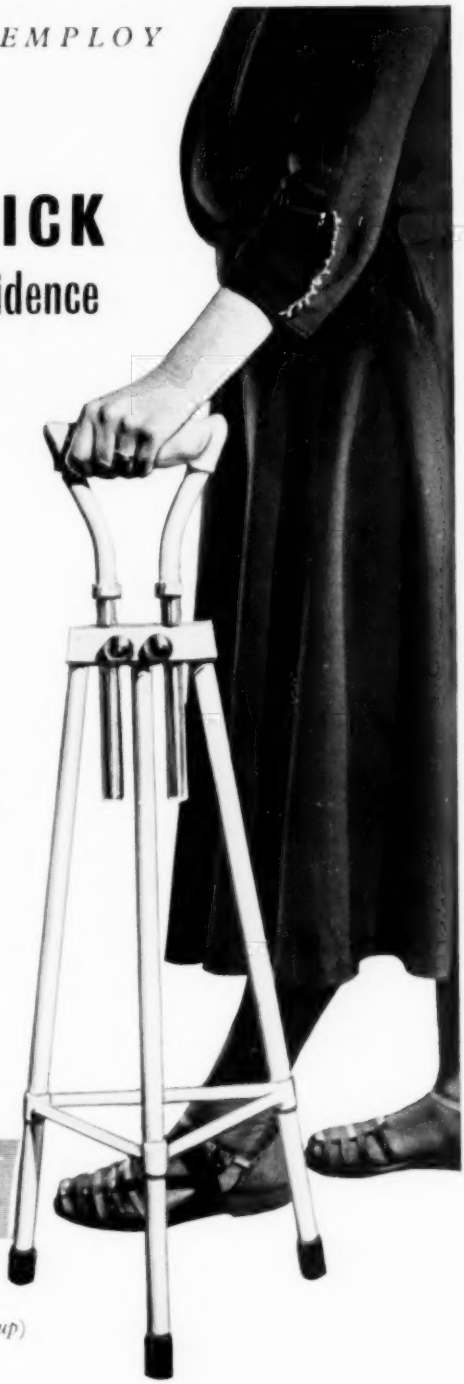

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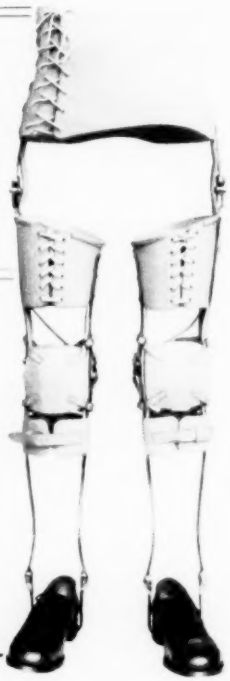

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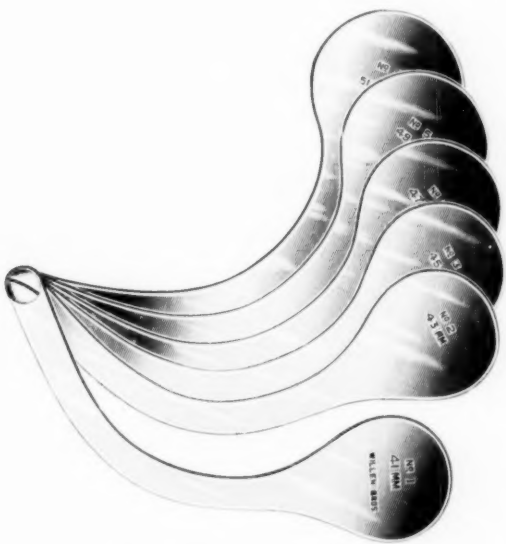

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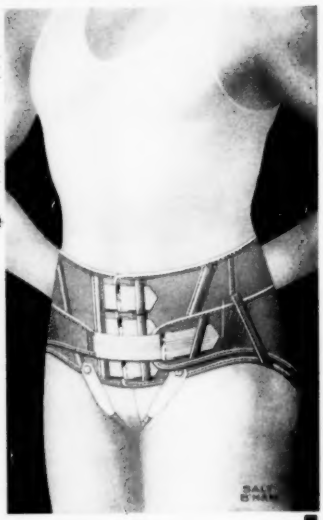

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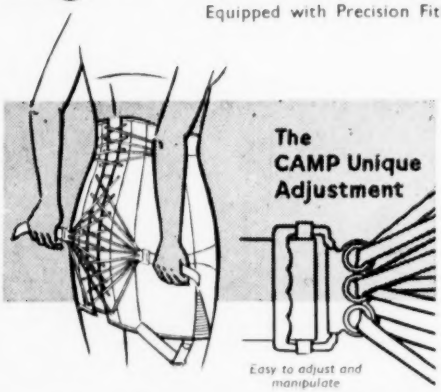

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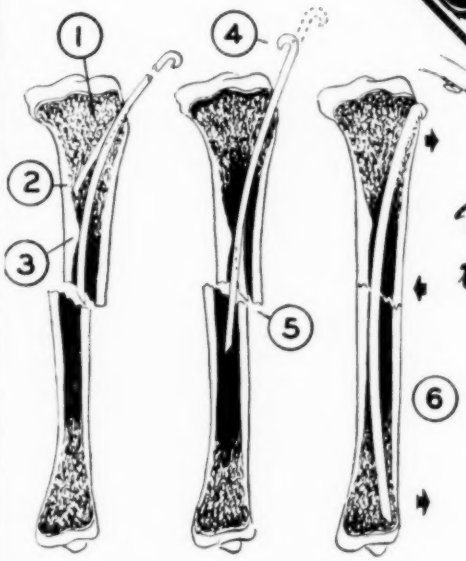

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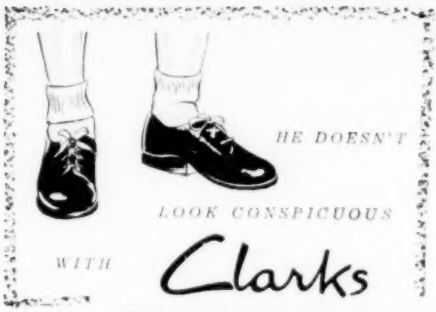

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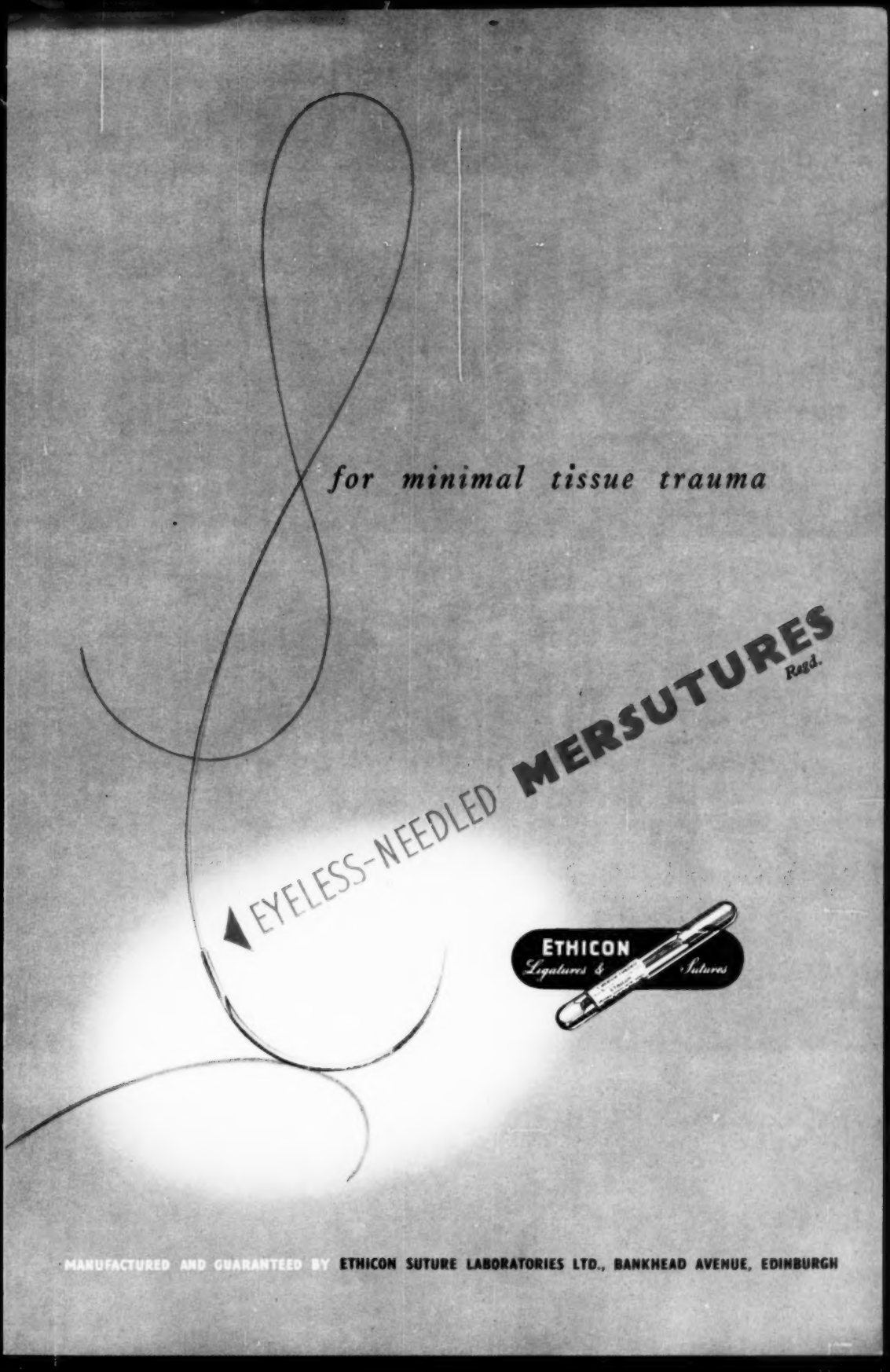

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